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INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1953

COMMONWEALTH MYCOLOGICAL INSTITUTE
4 SEP 1954

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Director's Report

Staff.—During 1953 the following additions have been made to the staff: Dr. N. B. Chanda, M.Sc., Ph.D, Biochemist, Mr. E. D. Heath, B.Sc., Advisory Officer designate, Cachar, Mr. M. J. Green, B.Sc, Botanist, Mr. M. C. Vanderputt, Personal Assistant to the Director.

Mr. D. N. Barua returned from study leave in the United Kingdom and has been awarded the degree of Ph. D (Cantab.) for his work on "The Effect of Light Intensity on the Growth and Assimilation of Tea Seedlings".

In May the West Bengal Advisory Branch was opened at Nagrakata in the Dooars with Mr. R. I. Macalpine, B. Sc. in-charge. Mr. A. D. Swan, B.Sc., replaced Mr. Macalpine as Advisory Officer, Darjeeling.

The Senior Physical Chemist (Soils) was on overseas leave from June to November inclusive. The Tea Taster proceeded on overseas leave in November.

The present senior staff is as follows :

R. J. McILROY	...	Director
W. WIGHT	...	Senior Botanist
N. G. GOKHALE	...	Senior Physical Chemist
D. J. WOOD	...	Senior Biochemist
S. K. DUTTA	...	Senior Agriculturist
G. M. DAS	...	Senior Entomologist
K. C. SARMAH	...	Mycologist
J. M. TRINICK	...	Tea Taster
I. McTEAR	...	Resident Engineer
M. J. GREEN	...	Botanist
N. B. CHANDA	...	Biochemist

Advisory Service.

P. M. GLOVER	...	Senior Advisory Officer, Assam
R. I. MACALPINE	...	Senior Advisory Officer, West Bengal
A. D. SWAN	...	Advisory Officer, Darjeeling
E. D. HEATH	...	Advisory Officer designate, Cachar (at Tocklai).

Buildings.—Two small bungalows have been erected for the Tea Taster and Botanist. An office and tasting room have been built for the Tea Taster.

One 27 K. W. A. C. generator has been installed in addition to the 55 K. W. A. C. generator and the Station was converted to A. C. electric supply at the end of the year.

An Implements Shed and a Manure Store have been constructed at Borbhetta Estate. The Engineering Workshop is now completed and in operation. The foundations are being laid for a unit-scale factory which will house a withering tunnel, the prototype of a continuous roller, and the prototype of a pneumatic drier.

Lecture Courses.—Two lecture courses for Planters were held between February 23rd and March 7th. Each course was attended by 30 Planters. A course on Vegetative Propagation was given at the end of April. Senior Officers and the Director assisted as usual in the courses on Tea given by the Assam Agricultural College.

Conference.—The Annual Tocklai Conference was not held in 1953 due to the visit of the Commission of Enquiry. This Commission which consisted of Sir Frank Engledow (Chairman), Messrs. E. J. Nicholls, R. L. Hards, and E. H. Adams with Sir Percival Griffiths (Adviser) and Mr. H. J. Walsh (Secretary) visited Tocklai from December 26th to January 4th.

Scientific Department Sub-Committee.—One meeting of this Committee was held at Tocklai during the year—on June 8th.

Other Meetings.—The Director attended the following meetings outside Tocklai during the year :

Annual General Meeting D.B.I.T.A. at Binnaguri—January 20th.

" " " I.T.A. at Calcutta—March 11th.

Scientific Department Sub-Committee at Calcutta—March 12th, and October 29th.

Annual General Meeting, Assam Tea Planter's Association at Dibrugarh—April 5th.

Scientific Department Sub-Committee and General Committee I.T.A. at Calcutta—May 13th to 15th.

London Advisory Committee, Development Panel and Scientific Panel in London—mid July to mid August.

Annual General Meeting A.B.I.T.A. at Panitola—November 21st.

Commission of Enquiry and Sub-Committee at Calcutta—December 9th & 10th.

Publications.—The following publications were produced during the year.

Tea Encyclopaedia Serial 98—"Safety Precautions with Air Pressure Retaining Knapsack Sprayers".

" 99—"Plant Louse attacking Plants in Nurseries".

" 100—"Fertilisers and Fertiliser Mixtures".

Revised Serials :

17/2—"Meteorological Instruments and Observatories."

25/1—"Optimum Soil Requirements for Tea to Flourish."

36/1—"Hail Damage on Tea Estates."

37/1—"Defects of Tip."

40/1—"Crotalaria anagyroides."

43/1—"Infilling and Treatment of Infills"

44/1—"Control of Pests and Diseases of Boga medeloa."

52/1—"Control of Mound-Building Termites"

53/1—"Medium Pruning"

55/1—"Withering and its Relation to Quality"

59/1—"Green Cropping Programme for Shading Tea Seed Nurseries"

61/1—"The Prevention and Cure of Red Rust"

65/1—"Branch Die-Back and Nectria"

69/1—"Tea Tasting Terms."

Work of the Station.—The activities of the Station during 1953 have been directed along the following lines :

Manufacture—The results of experiments on withering carried out in the air-conditioned chamber during the past year are reviewed by the Biochemist. It has been found practicable to wither in 3 hours and at greatly increased thickness of leaf spread. The experiments indicate that teas made from rapidly withered leaf give an inferior liquor in comparison with teas made from naturally withered leaf unless the rapid wither is preceded by a period of storage. The chemical changes which occur during withering are being studied.

The prototype of a continuous roller designed by the Resident Engineer is under construction, and will be tested during the coming season.

Modifications in firing machinery are being examined by the Resident Engineer and a pneumatic drier (Berk Ring Drier) at present en route from the United Kingdom will be tested on arrival.

Mechanisation—Trials are being carried out with plucking machines mounted on a frame which straddles the tea bushes and travels on horizontal rails. The object of these trials is to discover how the bush responds to regular machine plucking.

The trials wlll be continued throughout the 1954 plucking season When a suitable plucking machine is designed the same machine with appropriate attachments can be used for pruning, spraying, weeding and fertiliser application. It is considered that a machine mounted on a frame which straddles the rows has the best chance of success. Hedge planting of tea will facilitate the passage of a tractor propelled machine. In close planted (triangular formation) tea the lateral branches will have to be trimmed to permit passage of the machine.

Tea Culture—Analysis of the data obtained at Borbhetta on the yield of tea under different light intensities has shown that when the light intensity is reduced to between 50 and 70% of full light the yield of tea is significantly greater than for unshaded tea. The optimum light intensity lies between 50 and 70% for Assam kinds of tea. This increased yield was produced during the first year of shade. The experiment has also given useful information on the effect of the discontinuation of manuring under shade.

As a source of natural shade the relative efficiencies of seven different species of shade tree—*Albizzia stipulata* (Sau), *A. odoratissima, A. Procera* (Koroi), *Aleurites montana, Dalbergia assamica* and *Derris robusta*—were examined. The yield of tea was highest under *A. stipulata* (Sau) and *A. odoratissima.* The trials are being continued with further species of shade trees.

The distribution of large numbers of clonal plants to Gardens and the extension of pot culture experiments suggested the need for a standard potting medium. Several media were tested, including jungle soil, loam, turf soil and sub-soil. It was found that the medium consisting of a basis of sub-soil and sand with coconut fibre as organic matter and a fertiliser base made up of hoof and horn meal (2 parts), superphosphate (2 parts) and potassium sulphate (1 part) gave the best results.

Soils—The study of the base exchange properties of the main soil groups of North East India has been continued. It is considered that it may be preferable to describe the essential

soil condition for tea in terms of cation balance, for example, between aluminium and calcium, rather than in terms of hydrogen ion concentration (p.H).

Botany—The relation between taxonomic characters and yield and quality has been further studied. The best populations of plant appear to be those in which hair is associated with anthocyanin pigment in the leaf petiole. It has been shown that the weight and thickness of the stem and the density of the wood in the leaf petiole are related to the density of hair.

The effect of shade on leaf anatomy has been studied. Under shade the number of vessels is increased and the proportion of fibre reduced. The effect of manuring on these taxonomic characters has also been examined.

Tea Aroma—In a search for the chemical substance responsible for tea flavour and aroma ether extracts of leaf rich in aroma have been fractionated by column chromatography on alumina. Crystalline material isolated from the fractions is being subjected to rigorous chemical examination.

Hormone Weed Killers—Based on field trials the following recommendation is made concerning the spraying of thatch baris. When the majority of weeds are soft and non-woody, e.g. Ageratum sp., Fernoxone at the rate of 2½ lbs. per acre should be applied. When the majority of the weeds are of a woody nature, e.g. Urena sp., Rubus sp., Melastoma sp., the most satisfactory treatment is spraying with 2,4,5 T at ¼ gallon per acre.

Insecticides, Acaricides, and Fungicides—Laboratory and field trials with new synthetic insecticides, acaricides, and fungicides have been continued. Aramite has given promising results in the control of Red spider.

AGRICULTURAL BRANCH.

Staff.—S. K. Dutta, B. Sc., Senior Agriculturist, E. D. Heath B. Sc., Advisory Officer designate, Cachar.

Mr. E. D. Heath joined the Station in October and has since been in training with the Agriculturist.

Labour.—The average daily attendance during the year was :—

Tocklai	...	24.47
Borbhetta	...	333.46

Rice allowance was made during the year, based on the current market prices.

Crop Yield.—The total yield of green leaf during the year compared with that of 1952 was as follows :—

1952	...	2,46,184 lbs.
1953	...	1,93,073½ lbs.

Of the 1953 yield 1,45,517 lbs. was sold to .Messrs. Jorehaut Tea Co., Ltd. at Rs. 16/- per maund.

General plucking stopped on October 23rd.

Advisory.—The Agriculturist wrote 187 letters during the year in answer to technical queries.

Tours.—The Agriculturist visited 22 Gardens in the Dooars during November/December and 21 Gardens in the Assam Valley during the course of the year.

Publications & Lectures.—Four Tea Encyclopaedia Serials, Nos. 36/1, 40/1, 43/1, and 53/1 were published jointly by the Agriculturist and the Senior Advisory Officer, Assam.

The Agriculturist gave four lectures on Pruning and Plucking during the Annual Lecture Courses, and a series of lectures on Vegetative Propagation during two special courses on this subject in May.

Buildings.—A new Manure Godown (50 ft. x 25 ft.) and a new Implements Shed (50 ft. x 30 ft.) were erected during the year at Borbhetta.

Experiment to study the different forms of nitrogenous manures at different light intensities :

Introduction.—It is an established fact that most, if not all, Assam types of tea give an increased yield under leguminous shade trees. Part of this increase, however, is due to the benefit derived from leaf fall and organic nitrogen from the shade tree. In order to eliminate these factors, and to study only the shade factor, bamboo screens are being used instead of shade trees to provide shade of known varying densities.

Design of Experiment.—The following treatments are being studied.

Four types of nitrogenous manures viz. mustard oilcake, sulphate of ammonia, calcium nitrate and urea are being used in two different levels i. e. at 75 lbs. and 150 lbs. nitrogen per acre under three different light intensities i. e. 100% 70% and 50% light. There are therefore 24 treatments in all.

The experiment provides for the following comparisons :—

(a) Effect of three light intensities.

(b) Effect of each form of nitrogen at two levels.

(c) Effect of ammonia and nitrate nitrogen.

(d) Effects of organic forms and inorganic forms of nitrogen.

In this report the effect of the varying light intensities will be the main consideration.

The lay out is of the split plot design, split first for light and then randomised for the rest of the treatments in four whole blocks.

Analysis of Variance.

Within whole blocks.	Block	...	3
	Light	...	2
	Error	...	6
Within sub-blocks	Form of nitrogen	...	3
	Dose of nitrogen	...	1
	Form x Dose of nitrogen	...	3
Within sub-blocks	Light x Form	...	6
	Light x Dose	...	2
	Light x Dose x Form	...	6
	Error	...	63
	Total	...	95

Details of the Experiment.—The tea was planted in November 1935 in Area No. 8 of the Borbhetta Field Experimental Estate and this tea was under a pruning experiment from 1937 to 1943. For that experiment, the land was divided into 5 blocks, each with 12 plots bounded by bunds and drains. Each plot had 8 x 12 = 96 bushes, planted at $4\frac{1}{2}'' \times 4\frac{1}{2}''$ triangular.

(*a*) *Plots*—In the present experiment, the old plots were split into two. Each new plot has 48 bushes, of which 24 bushes receive the treatment of the particular plot and the other 24 bushes form the Guard Line round it. The old blocks containing 12 plots each, now therefore contain 24 plots having all the 24 new treatments.

(*b*) *Manuring*—The manures were applied broadcast by hand over the whole of each plot on 14th July 1952.

(*c*) *Plucking*—The tea was pruned between 11/2/52 and 14/2/52 by leaving half an inch of new wood above the previous pruning level. It was tipped at 8 inches above this level and plucked to the *janam* till 19th October 1952 (i. e. plucking of all growth above the tipping level except that the *janam*

leaf was not plucked, if it happened to be above the tipping level. *Janam* leaf is the small unserrated leaf that is formed by the outer scale of the dormant bud, when it commences to grow again).

(*d*) *Records*—The weight of leaf plucked weekly was recorded immediately after plucking.

Shade.—The tea had no shade prior to the commencement of this experiment. Bamboo screens made from 1 inch wide and $\frac{1}{8}$ inch thick strips with 3 inches space give about 70% light. Screens 1 inch wide with $\frac{1}{8}$ inch thick strips and 2 inch space give 50% light. These screens have been placed 6 feet above the tea supported on bamboo posts and frames. Each block has three parallel sub-blocks containing 8 plots, each receiving the three light intensities i.e. full light (no screen), 75% light, and 50% light.

The frames were erected between 23/2/52 and 3/3/52. Manures were not applied till 14th July 1952, by which time the second flush was over and it was too late to get the full benefit of the manure in the year of application. Hence, in this report, the effect of light intensities only is being considered, and that on the gross yield of the plucked leaf only.

Results.—*Weight of leaf*—Leaf consisting of all shoots of two leaves and a bud above the plucking surface was plucked and weighed weekly from April to 15th October 1952. The leaf weighments were recorded in pounds and eventually the total yield for 1952, was converted into maunds (80 lbs. =1 md.) of made tea per acre.

1952 CROP.

Maunds made tea per acre.

Light x Manure x Dose.

Form of Manure	Light. Nitrogen per acre.	100%	70%	50%	Mean.
Mustard Oilcake	75 lbs.	5·69	8·02	7·65	7·12
	150 lbs.	7·46	8·30	7·93	7·89
Sulphate of Ammonia	75 lbs.	6·62	9·04	8·02	7·89
	150 lbs.	6·25	9·14	8·11	7·83
Calcium Nitrate	75 lbs.	5·78	8·20	8·95	7·64
	150 lbs.	6·15	8·30	7·93	7·46
Urea	75 lbs.	6·34	8·20	8·20	7·58
	150 lbs.	6·53	9·04	8·67	8·08
Mean		6·35	8·53	8·18	

The difference required for significance at 1% level for the yields under different light intensities is 1.62 mds.

Discussion.—It is seen from the table that the effect produced by the reduced light intensities is highly significant (P = .01). The yield of the tea under reduced light intensities of 70% and 50% of the full light is significantly higher than that of the tea without any shade at all. Reduction of the light intensity to 50% from 70% has not, however, shown any further increase in yield. It has, of course, not shown any reduction in yield either. This is helpful, as when shade is provided by trees, it is difficult to obtain an exact density at all times. However, the optimum light intensity is likely to vary for different kinds of tea.

The increased yields in this experiment have been obtained in the very first year of introduction of shade, which indicates that the effect of shade is rapid and definite. In commercial

tea estates, it is not economical to erect artificial shade and shade is provided by growing shade trees. When shade trees that do not compete with the tea for nitrogen e.g. the nitrogen fixing leguminous shade trees like *Albizzia stipulata, Albizzia odoratissima* etc. are grown, the added advantage of addition of nitogen and general improvement of the soil is obtained, and the increase in yield can only be even more pronounced.

The trees of different species have varying rates of growth and different shapes and sizes of canopy. Furthermore, even trees of the same species grow at varying rates and have different sizes according to the soil and climate. If the shade density is to be kept constant irrespective of these factors, it is only natural that the distance apart of planting shade trees will vary according to the soil, climate and kind of shade tree used even for the same kind of tea.

Measurements of shade density given by different species of shade trees of varying sizes and the amount of nitrogen provided by these trees in addition to the applied nitrogen, is the subject of another experiment.

Summary—

(1) When the light intensity was reduced by 30%, a yield of 34% more plucked leaf was obtained than when the tea was grown in the full light i. e. in the open without any shade.

(2) This increase in yield was obtained by providing artificial shade by erecting bamboo screens over the tea bushes.

(3) The increase was obtained in the very first year of providing the shade.

(4) A further reduction of the light intensity to 50% of the full light, did not produce any further increase in yield.

Experiment to study the effects of different species and heights of shade trees on the light intensity and yield of Tea.— For this experiment an area was planted with 1-year old

seedlings of an Assam type of tea in 1939, and the following species of shade trees were planted in 1941.

1. *Albizzia stipulata* (with Green stipules).
2. *Albizzia stipulata* (with Red stipules).
3. *Aleurites montana.*
4. *Dalbergia assamica.*
5. *Albizzia procera.*
6. *Derris robusta.*
7. *Albizza odoratissima.*

The effects of the individual species of the shade trees will be dealt with at a later date. The effects of manures, however, are being dealt with later in this report.

Design of the Experiment.—The layout is a split plot design, where it has been split first for four manuring treatments and then the shade trees have been randomised.

Each plot is of a hexagonal shape and consists of 108 tea bushes (but the central bush has been replaced by the shade tree). There are sixteen repeats of each shade tree (and four repeats of each manuring treatment), but for the study of the heights and light intensity only eight repeats were used.

Details of the Experiment.—Light intensity readings were measured in foot candles by means of an exposure meter and recorded at intervals of approximately 5 weeks throughout the year. It was measured on five points along the North-South diameter of the hexagonal plot. The readings were always taken between 10 a.m. and 3 p.m. on clear days and the recordings in the period between 23/4/52 and 15/10/52 were used for the analysis.

The heights of the shade trees were determined in June 1952 by means of a theodolite.

Leaf yield of each plot was taken at weekly intervals from each of the $8 \times 8 = 64$ plots under this observation.

Records taken in 1952.

Average Light Intensity, Height of Shade Tree and Crop.

Shade tree	Plot No.	Average light.	Height of shade tree. in ft.	Crop in lbs.	Shade tree	Plot, No.	Total light	Height of shade tree in ft.	Crop in lbs.
Albizzia stipulata (Red)	9A	2950	31	136	*Derris robusta*	9D	3083	20	121
	9G	1775	52	217		11A	2762	Vacant	147
	10C	2254	37	179		11F	1531	42	194
	12F	1804	49	228		11G	2275	30	138
	13C	1867	48	219		13B	1829	46	170
	16B	3300	Vacant	150		13F	939	56	212
	16E	2321	39	179		14H	1569	46	236
	16H	1462	39	187		16C	2342	25	144
		17733	295	1495			16330	265	1412
Albizzia stipulata (green)	9C	3129	50	125	*Albizzia odoratissima*	11E	3433	Vacant	177
	10F	2483	31	164		12B	2033	54	194
	10H	2004	30	201		12C	2225	45	203
	11B	2017	44	161		12G	2083	55	238
	14A	2704	40	163		14F	1579	54	208
	15H	2250	42	253		14G	1542	69	222
	16D	2317	16	154		15A	2696	Vacant	143
	16F	2458	36	192		15D	1654	43	176
		19362	289	1413			17245	320	1561
Aleurites montana	10E	3021	28	152	(CHECK) No shade tree	9B	3688		131
	11C	1750	35	150		9F	3600		135
	11H	1717	31	148		9H	3660		174
	12A	2158	32	152		12D	3021		189
	13A	2246	26	153		14B	3225		167
	13G	1675	38	197		15E	2883		184
	13D	933	39	203		15C	3117		156
	14E	1174	41	171		16G	3517		147
		14674	270	1326			26711		1283

Records taken in 1952.

Average Light Intensity, Height of Shade Tree and Crop.—(*Contd.*)

Shade tree	Plot No.	Average light.	Height of shade tree. in ft.	Crop in lbs.	Shade tree	Plot No.	Total light	Height of shade tree in ft.	Crop in lbs.
Dalbergia assamica	10A	1150	45	134					
	10G	2042	32	179					
	11D	2221	32	169					
	12E	2704	65	207					
	13E	1729	65	201					
	13H	1700	46	218					
	14C	1842	44	191					
	15B	2521	36	133					
		15909	365	1432					
Albizzia procera	9E	2506	45	151					
	10B	2500	39	135					
	10D	2558	52	174					
	12H	2059	50	230					
	14D	2467	34	189					
	15F	2812	46	182					
	15G	2283	45	204					
	16A	2454	40	154					
		19639	351	1419					

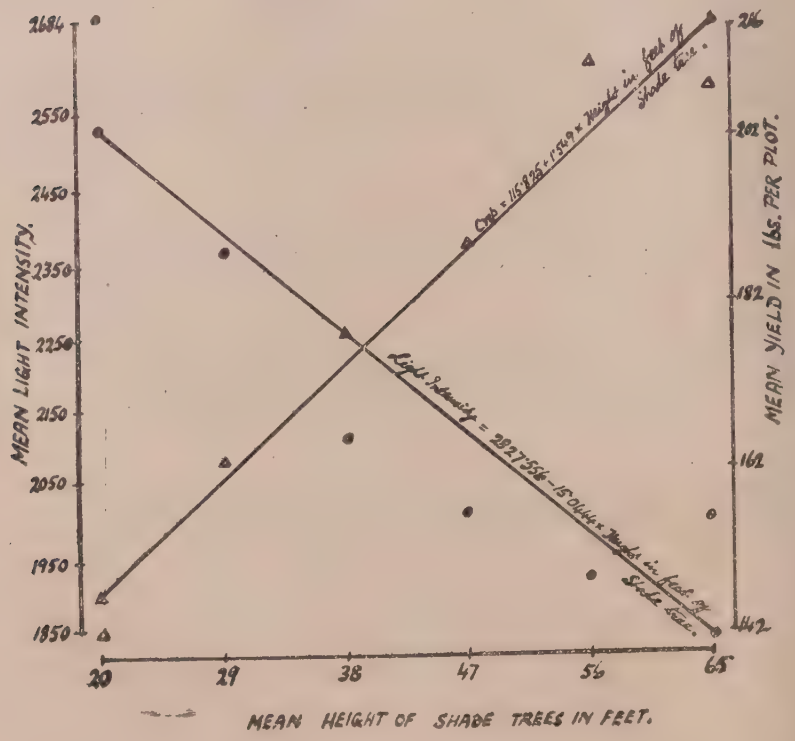
Relation of height of shade trees with light intensity and yield of tea.—(a) It has been found that the average light intensity on a plot of 108 bushes depends on the height of the shade tree there, in all the species used. The average light intensity of all the species of shade trees used, in this experiment, decreased by 15·0444 foot candles for each foot increase in height.

(b) The actual decrease in light intensity for each unit increase in the heights of the shade trees of different species will usually vary. This will also depend on environmental conditions.

(c) The average yield of green leaf in pounds per plot of 108 bushes was found to have increased by 1·549 pounds for each foot increase in height of the shade trees of the different species, taken as a whole.

(d) The actual increases in yield for each unit increase in height of the shade trees will depend upon the species of the shade tree used and other environmental conditions.

This is graghically represented as follows :—

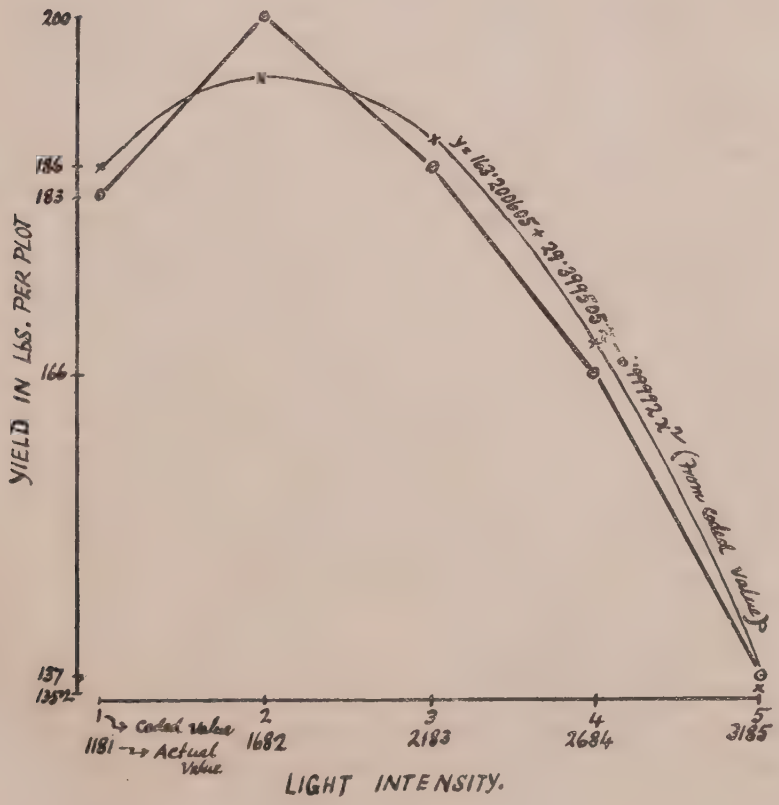


The average effect can be interpreted as follows :—

For each foot increase in height of shade trees, yield increased by 1.549 pounds of green leaf per plot of 108 bushes and the light intensity increased by 15.0444 foot candles. These figures are applicable to conditions of this experiment only.

Effect of varying light intensities on yield of tea.—The following is a graph made from records of plots excluding the check and vacant plots, as the check plots were found to have received benefit of shade from the adjoining plots and the present vacant plots had received benefit in the past years from the then standing trees although light intensities recorded in 1952 were high. The records of the plots with small trees giving very little shade have, however, been included.

GRAPH II



3

In the previous account concerning another experiment with artificial shade, it was stated that, under reduced light intensities of 70% and 50% of full light, the yield was significantly higher than that of the tea without any shade at all.

From the graph above, it is seen that in this experiment the optimum yield has been within the range of 1181 to 2200 foot candles of light intensity, which is approximately between 33% and 60% light. It also shows that the maximum crop is being obtained at about 50% light. These data also show how yield of tea can vary according to the nature of shade.

General.—The observations made here were on only a few trees and it is very likely that when large areas under a pure or mixed shade are observed, the actual light intensities recorded in relation to the heights of shade trees may be quite different. But this is not likely to alter the trends of the different relationships. It is hoped, however, that during 1954 a start will be made in the study of all these factors in some representative commercial tea estates containing various stands of pure and mixed shade. Only the data obtained from such observations are likely to be applicable to commercial estates.

Experiment to study the effect of different species of shade trees and phosphate and potash.—This experiment was originally designed to study the efficiency of seven different species of shade trees and also the effect of phosphate and potash. The efficiencies of the different species of trees used have already been established to a very large extent (vide our Annual Report—1946). It was then decided in 1950 that the shade densities given by the trees of the different species, and also by the trees of different heights and spreads be observed. It was also decided to collect samples of leaf droppings of the trees by placing three baskets of a given diameter 6 feet away from the centre of the tree at equal angular intervals around the tree in each of the plots. From these samples, the amount of leaf fall per acre can be calculated and also the amount of nitrogen added per acre by each of the species of any size.

Weighment and analysis of the leaf droppings of the shade trees have not yet been completed owing to temporary lack of facilities. The results of these aspects will, therefore, be dealt with in a later report, upon completion of the analysis etc.

All the plots were manured with a constant level of nitrogen till 1947, but the application of nitrogen was discontinued from 1948, so that the true effects of the shade trees of the different species could be studied.

Two series of treatments have been introduced here as follows :—

Series A.—1. 40 lbs. of potash per acre.

2. 40 lbs. of phosphate per acre.

3. 40 lbs. of potash and 40 lbs. of phosphate per acre.

4. No manure.

Series B.—1. *Albizzia stipulata* (with Green stipules).

2. *Albizzia stipulata* (with Red stipules).

3. *Aleurities montana.*

4. *Dalbergia assamica.*

5. *Albizzia procera.*

6. *Derris robusta.*

7. *Albizzia odoratissima.*

8. No shade trees.

The layout of the experiment has been described in the introduction to the previous experiment

The structure of the analysis of variance table is as follows :—

		D, F.
Whole plots	Blocks	3
	Manuring treatments	3
	Error	9
Sub-plots.	Shade	7
	Manuring treatments x Shade	21
	Error	84
	Total	127

Results.—

A. Effect of Phosphate and Potash :

TABLE I.

Maunds of made tea per acre.

YEAR	1946	1947	1948	1949	1950	1951	1952
Treatments. Nitrogen per acre.	80 lbs.	80 lbs.	Nil	Nil	Nil	Nil	Nil
No phosphate and no potash ...	19.32	17.22	19.75	18.21	15.97	11.13	9.22
40 lbs. phosphate per acre ...	19.78	17.12	19.56	18.90	16.68	11.54	9.90
40 lbs. potash per acre ...	20.09	17.76	19.55	18.56	16.05	11.28	9.63
40 lbs. phosphate and 40 lbs. potash per acre	20.04	17.65	20.19	19.32	16.85	12.17	10.38
Significant difference required at 5% level ...	2.07	2.06	2.22	1.79	1.72	1.82	1.65

The figures in Table I show that, irrespective of whether phosphate and potash are applied singly or together, and whether they are applied with double the dose of nitrogen or not, they do not produce any increased yields of tea at the levels applied.

B. Effect of shade trees and nitrogen—

Yield Records—The tea has been plucked to remove leaf consisting of two leaves and a bud above an initial height of 8 inches, at weekly intervals during the season. These are recorded in pounds and converted into maunds (80 lbs. = 1 maund) of made tea per acre.

The following is an annual yield table for tea under the different species of shade trees, since 1946.

TABLE II.

Maunds of made tea per acre.

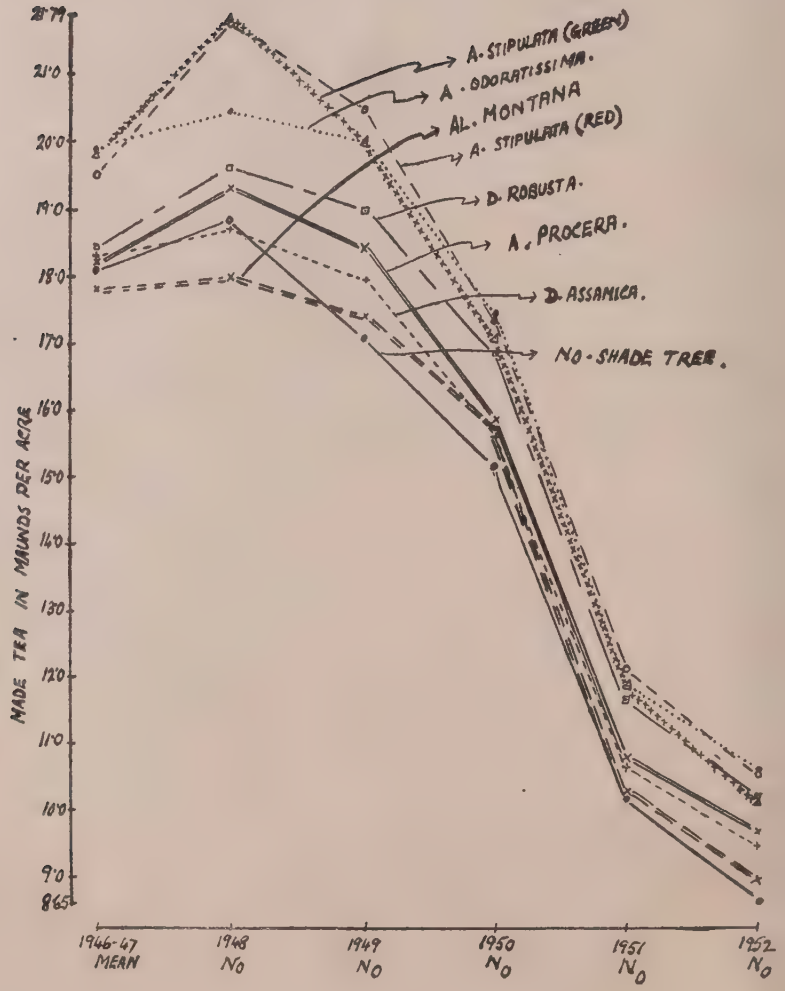
Species of shade trees	YEAR	1946	1947	1948	1949	1950	1951	1952
	No. of plucking rounds.	31	35	34	32	32	—	—
	Nitrogen per acre.	80 lbs.	80 lbs.	Nil	Nil	Nil	Nil	Nil
No shade tree ...		19·74	16·24	18·74	17·06	15·18	10·52	8·65
Aleurites montana ...		18·77	16·76	17·96	17·35	15·75	10·62	8·98
Albizzia stipulata (Red) ...		20·46	18·46	21·69*	20·41*	17·39*	12·48*	10·52*
Albizzia stipulata (Green) ...		20·60	18·82	21·79*	19·96*	17·06*	12·25*	10·14*
Albizzia odoratissima ...		20·39	18·92	20·34*	19·94*	17·43*	12·27*	10·60*
Albizzia procera ...		19·20	17·02	19·27	18·36	15·83	11·07	9·72*
Derris robusta ...		19·74	16·89	19·56	18·94*	16·84*	12·03*	10·20*
Dalbergia assamica ...		19·74	16·73	18·72	17·92	15·58	10·98	9·46
Significant Difference required at 5% level		1·33	1·73	1·45	1·49	1·57	1·22	0·93

*indicates significantly higher yields than under no shade.

From the annual yield table above, it is seen that *Albizzia odoratissima* and the two types of *Albizzia stipulata* have remained the more efficient trees every year since 1947. The tea under *Derris robusta* started to yield significantly more from 1949, and in 1952 all the trees except *Aleurites montana* and *Dalbergia assamica* proved to be efficient. *Aleurites montana* is the only non-leguminous tree used in the experiment, and *Dalbergia assamica* remains leafless for nearly six months in the year, as the leaf starts to fall at the end of December and the trees do not come into leaf till about the end of June.

The figure in the page following, shows the efficiencies of the different shade trees and the effect on the yield of tea when the application of nitrogen was stopped :—

EFFECT OF DIFFERENT SHADE TREES ON CROP ON CEASING TO MANURE



It is observed that in the first year of no manure application, there was no loss in yield under any of the treatments including no shade. Actually it maintained a steady increase over the previous years. This is explained because the tea was young and the cumulative effect of the manures applied in the previous years remained. It is, however, interesting to note that the yields of the tea under *Albizzia stipulata* (Red), *Albizzia stipulata* (Green) and *Albizzia odoratissima* remained well above the yields of the tea under the other species of shade trees and no shade. From the second year of no manure application, the tea under *Derris robusta* also gave significantly higher yield than the tea under *Albizzia procera, Dalbergia assamica, Aleurities montana* and no shade (Table II). *Derris robusta* (which was fourth in the order of merit in 1949, and missed being a significantly efficient tree) proved its use in 1949. It was, however, not as good as the two types of *Albizzia stipulata* and *Albizzia odoratissima.* From this year (1949), it can be seen from the figure that *Albizzia stipulata* (Red), *Albizzia stipulata* (Green), *Albizzia odoratissima* and *Derris robusta* formed a separate group from the rest and followed the same trend till 1952 ; however, the tea under *Albizzia procera* which was fifth in the order of merit previously, also became significantly better than *Dalbergia assamica, Aleurites montana* and no shade. *Dalbergia assamica,* the only remaining leguminous tree, just missed being a significantly efficient tree in 1952.

As has already been mentioned, it can be seen from the figure that there was no loss of crop in any of the tea in the first year of no manure application (1948). Actually, there was an increase, and this increase was highest in the cases of the two types of *Albizzia stipulata.* The reason why the increase was not high in the case of *Albizzia odoratissima* in this particular year is not understood.

In the second year of no manure application, i. e. in 1949, the tea without shade showed a steep decline in yield. The tea under *Aleurities montana* and *Dalbergia assamica* also showed a decline. The benefit of the nitrogen applied two years ago could still be observed in the tea under *Albizzia stipulata* (Green) *Albizzia stipulata* (Red), *Albizzia procera, Derris robusta* and *Albizzia odoratissima.*

In the third year of no nitrogen application, i. e. in 1950, there was a decline in the yield of tea under all the shade trees, and by 1952 the yield had become half of what it was in 1946/1947.

Discussion.—It has been shown that reduced light intensities produce significantly higher yields in Assam types of tea. It was also suggested that when efficient nitrogen fixing trees are used for providing the shade, the effect can only be even more pronounced.

The figures in Table II and Graph give us the following information :—

1. *Albizzia stipulata* (Green), *Albizzia stipulata* (Red) and *Albizzia odoratissima* are the three most efficient trees amongst the ones used in this experiment.

2. Benefit from the application of Sulphate of Ammonia remains till the year after application of the manure both in shaded and unshaded tea.

3. Some of the benefit can be observed for an extra year in tea that is under a more efficient species of shade tree.

4. Tea under the leguminous, nitrogen-fixing, species of shade trees used, benefit from their shade, but the time taken to become efficient varies inversely with the efficiency of the trees i. e. a tree of low efficiency takes longer to produce its benefit to the tea.

5. *Dalbergia assamica* is a tree of low efficiency, but the indications are present that if left long enough, the tea under it may produce significantly higher yields than tea without any shade trees.

The low efficiency may be explained by the fact that this tree remains leafless for nearly six months in the year and thus is not a very useful shade-giving tree.

6. *Aleurites montana*, the only non-leguminous tree used in this experiment, is not benefitting the tea at all, as the yield of the tea under this tree has always been about the same as the tea with no shade.

This is possibly because such benefit as the tea under this shade receives is being offset by the fact that the tree is drawing all its nutrients from the soil without fixing any nitrogen from the air.

This finding does not support the view held by some, that any tree which gives shade is good enough. In the opinion of the writer, such trees may be of use only if extra manure is supplied to these trees,- but that would be an unnecessarily wasteful method.

Standardisation of Potting Medium.—***Introduction.***—As more and more plants have to be raised in pots both for experiments and distribution of plants to Gardens, standardisation of the potting medium is of the utmost importance. Standardisation is necessary, so that failure or non-uniform growth of plants in different pots (or baskets) and in different seasons is eliminated, in so far as the soil is concerned, and the success of plants thereafter is assured. The Planters also will be more likely to get plants of standard growth.

The potting medium must have the following properties :—

(a) Good crumb structure and adequate moisture holding capacity.
(b) Balanced nutrient content.
(c) Free from toxic substances.
(d) Materials used should be cheap and readily available.
(e) Uniformity of materials so that the medium is exactly the same each time it is made up.

The following soil bases have been tried in various combinations with sharp sand, coconut fibre, jute fibre, cattle manure, and fertiliser base.

(a) Jungle soil.
(b) Ordinary loam.
(c) Turf soil.
(d) Sub soil.

Organic Matter.—It is essential for the composting medium to have sufficient organic matter. It should be clean and free from disease and weed seeds etc. and it should be such that it decomposes slowly. Cattle manure is not always desirable because it is not sterile and is likely to introduce disease organisms into otherwise sterile composts. Its value also varies with the quality of the manure from which it is made.

Nutrients.—Cattle manure is not likely to be the best nutrient supplier because the balance of nutrients it contains may not be the optimum. Fertiliser bases with different proportions of N. P. K. are likely to be more efficient. The mixture should contain such substances that some nutrients become readily available and others become gradually available over a longer period.

Fertiliser Base.—The fertiliser base used in this experiment was made up as follows :—

Hoof & Horn Meal	...	2 parts by weight.
Ordinary superphosphate	...	2 ,, ,, ,,
Sulphate of potash	...	1 ,, ,, ,,

Experiment.—The experiment was a simple randomised layout. Two clones were used, one a China hybrid type, and the other an Assam type, with 8 replications of each clone. Ten treatments were incorporated.

The clonal plants used were 6 months old, and of uniform size when put into pots containing the potting medium. After 9 months, i. e. at 15 months old, the height of the plants was measured, and this taken as the criterion for assessing the growth made during the 9 months. The check plants were in the usual potting medium of ordinary loam and cattle manure.

Results.—The best potting medium was found to be one composed of the following :—

Sub soil	...	7 parts by bulk.
Coconut fibre	...	3 ,, ,, ,,
Sharp sand	...	2 ,, ,, ,,
Fertiliser base	...	5 lbs. per cubic yard.

This gave plants which were 99.3% better than the check, and 54.7% better than the average of all other treatments, for both the China hybrid and Assam clones used.

This above potting medium may be prepared as follows :—

The sub-soil should be composted for 6 months by stacking it in alternate layers with strawy cattle manure. The thickness of the soil layers is 4 inches and that of the strawy cattle manure is 1 inch. The stocks should be 4 feet high, and 6′ x 4′ at the base. After 6 months, cut the stacks in slices from top to bottom to ensure thorough mixing. Before use, put the soil through a $\frac{3}{8}$″ sieve and sterilize.

Then spread the soil on the floor, and spread the coconut fibre evenly on top, then the sand and lastly the fertilizer base. Ensure thorough mixing before putting the medium in pots.

The effect of nitrogen under shade on the characters and valuation of made tea.—This experiment was originally designed to study the effect of shade and nitrogen on 12 different *jats* of tea. The tea was planted in 1936, and where shade is used, this is partly *Albizzia stipulata* and partly bamboo screens, giving approximately 50% light intensity. The layout is randomised blocks, and consists of three main blocks each of four sub-blocks. Each sub-block contains 12 plots, so that each *jat* appears once in each sub-block.

For the purpose of the present experiment, we are concerned only with a part of one main block, i, e, a sub-block which is entirely shaded by bamboo screens (50% shade) in which 6 plots received no nitrogen, and 6 plots received 100 lbs. nitrogen. Leaf was plucked on a weekly round throughout the season, but leaf from only 10 rounds was utilised in the experiment. On each occasion, this was bulked into two samples, i. e. all leaf from the nitrogen plots and all leaf from the no nitrogen plots. Each bulk sample was thoroughly mixed and a 25 lbs. sample drawn from each for the experiment.

The leaf was manufactured at Tocklai on ten different dates between 12th May and 26th September 1953, and the made tea was tasted by the Tocklai Tea Taster and a panel of Tasters from three Broking firms in Calcutta. The characters studied were strength, quality, briskness, quality of tip, colour of tip, appearance of dry leaf, colour of liquor, colour of infused leaf and valuation.

For the sake of clarity, the results obtained on each of the 10 different dates have been grouped together into one table, which appears below.

Taster's reports on 1953 manufactured tea.

Tasters	Quality	Strength of Liquors	Brisk-ness	Quality of TIP	Colour of TIP	Dry leaf	Colour of Liquor	Infused Leaf	Value-ation in pies	Valuation Rs.	As.	P.
Tocklai	575	775	625	514	525	500	650	533	3627	1	14	3
No. N Calcutta	475	600	475	614	625	775	700	550	3984	2	1	3
Tocklai	450	650	625	464	525	525	575	506	3564	1	13	9
100 lb. N. Calcutta	450	525	500	599	550	875	550	400	3924	2	0	9
S. D. reqd. at 5% level		184.7 (N* T*)	97.9 (T*)			386.81 (T*)	147.23 (N*)	146.06 (N*)	175.3 (T*)			

N*—Nitrogen significant
T*—Taster significant

For each of the characters studied, the tasters made specific assessments, e. g. for quality, the liquor was assessed as either good, medium or poor or intermediate between any two of these giving five possible assessments. For the purpose of statistical analysis, we allotted marks to each assessment, there being 100, 75, 50, 25 and 0 respectively. The figures in the table above are totals of these marks for each of the ten dates.

The results show once again that the application of as much as 100 lbs. nitrogen per acre as Sulphate of Ammonia has no effect whatsoever on quality. Briskness, tip, nature of the dry leaf, and valuation also are unaffected by 100 lbs. nitrogen per acre. The only significant effect of nitrogen was found to be on the colour of liquor and infused leaf and in both cases, this was only found to be significant, by the Calcutta Tasters. A slight deterioration was detected by the Tocklai Taster, but it was not significant. It is important to note, however, that the valuation of the made tea was not significantly affected by the application of 100 lbs. nitrogen per acre. Tocklai and Calcutta Tasters recorded a valuation difference of only 6 pies in favour of the no-nitrogen teas.

Tasters differed significantly in their assessment of briskness, dry leaf, and valuation, but this difference was constant in each case, that is to say, if the Tocklai Taster's valuation was lower than the Calcutta Tasters for the no-nitrogen teas, it was correspondingly lower for the nitrogen teas.

Briefly summarising then, under the conditions of this experiment, the application of 100 lbs. per acre of nitrogen slightly reduced the strength and colour of liquors, and caused a slight deterioration in the infused leaf, but the actual valuation of the tea was not significantly affected, due probably to the slight but insignificant improvement in the briskness and dry leaf.

The effect of shade on the characters and valuation of made tea.—The leaf used in this experiment was taken from an area of Assam *jat* planted in 1935. The main purpose of the experiments in this area is to study the effect of various forms of Nitrogen (viz. Oilcake, Sulphate of Ammonia, Calcium Nitrate and Urea at two levels—(75 lbs. and 150 lbs. nitrogen per acre)

under three different light intensities (100%, 70% and 50% light, or 0%, 30% and 50% shade). The shade is provided by bamboo screens.

In order to study the effect of shade on the various characters of made tea, bulk samples were taken from all the manurial plots in the no-shade block, and from all the manurial plots in the 50% shade block. (No leaf was used from the 30% shade block. The only difference, therefore, between samples was the shade factor. Leaf from 9 of the weekly plucking rounds was used, and this was thoroughly mixed each time, 25-lb. samples being obtained from both the shade and no shade leaf for manufacture.

As in the experiment—reported above—on the effects of nitrogen on made tea characters these teas were also tasted and assessed by the Tocklai Taster, and by a panel of Tasters in Calcutta, and the method of allotting marks (for the purpose of statistical analysis) for the various grades was also the same. In this case, leaf was manufactured from 9 plucking rounds between 22nd May and 10th October 1953.

The results are presented overleaf :

Taster's Report on 1953 Manufactured Teas.

Light Intensity	Tasters	Quality	Strength	Brisk-ness	Quality of Tip	Colour of Tip	Dry leaf	Infused leaf.	Colour of liquor	Valua-tion in ps.	Valuation. Rs. As. P.
50%	Tocklai	525	750	575	464	775	225	481	575	3327	1 15 0
	Calcutta	525	675	525	627	600	675	437	800	3768	2 3 0
100%	Tocklai	550	475	600	481	775	225	559	400	3258	1 14 0
	Calcutta	525	450	675	647	600	525	511	500	3810	2 3 3
S.D. at 5% level			225·1 (S*)		177·3 (T*)				195·5 (S*T*)	184·3 (T*)	

S*—Shade significant.
T*—Taster significant.

These results show that quality, briskness, colour of tip, dry leaf and infused leaf were not significantly affected by shade, but that strength and colour of the liquors were greatly improved at the reduced light intensity. This improvement was significant even at the 0·1% level.

Tasters again differed in one or two respects, but from the point of view of effect of shade, the value of the made teas was not affected.

It may be reasserted then, that under the conditions of the above two experiments, neither shade nor nitrogenous manuring, as described, has any affect on the ultimate value of made teas. Any increase in crop which results from such shade or manuring is not, therefore, obtained at the expense of quality.

BOTANICAL BRANCH.

Staff.—W. Wight, Ph.D., Senior Botanist, M. J. Green, B.Sc., Botanist.

Mr. M. J. Green joined the staff on the 22nd October. Mr. D. N. Barua has been successful in obtaining his Ph.D. from Cambridge University.

56 Memoranda have been written by the Senior Botanist during the year.

Vegetative Propagation—***Pretreatment and packing of cuttings.*** Previous work on the pretreatment and packing of cuttings has been summarised, and a brief survey of the most important findings is given here.

The large-scale distribution of clonal material is rendered difficult by the drying out of the cuttings. Large quantities of these cuttings must be prepared, packed and transported, and by the time they are ready to be planted, most will have become desiccated, and many damaged.

It was found that prevention of desiccation is dependent upon the nature of the packing media, and early experiments suggested that charcoal would be the best material for this purpose. The main value of charcoal was found to be the physical way

in which the moisture was held, since when other materials were used, the application of water even by an atomiser was found to be deleterious. One serious disadvantage in the use of charcoal is that the cuttings tend to suffer considerable physical damage.

100% increase in success is obtained if the cuttings are held in Alkathene packs, which slide over one another without the enclosed cuttings rubbing against each other. A slight extra increase in success is obtained if, before sealing in the Alkathene, the leaf blades are dipped in water.

Resistance to desiccation can be built up if the cuttings are first planted in propagation beds for 4-5 weeks. This is the standard period, and the process is known as pretreatment.

Growth and Yield—***Leaf area and leaf dry-weight***—Four experiments have been analysed to show the relationships existing between the areas and dry-weights of tea leaves, both in respect of agrotype index (see further in this report) and of various manurial treatments.

Leaves were marked when they were the third leaf on the stem, and at a standard stage of development. Some of these were use to obtain the first measurements, while the remainder were left for a period of 10 days, after which some were selected so that, again, only those at the same stage of development were chosen. These latter leaves, which by this time had become the fifth leaf on the stem, were used to obtain the data for the mature leaves. Thus at all stages, the leaves were strictly comparable.

Since the experimental areas did not contain the same number of plants, the measurements for each area are not comparable except by proportion. Dry-weights are given in gms., and areas in sq. cm. as measured by a planimeter. The $\frac{\text{area}}{\text{dry wt.}}$ figures represent the sums of these ratios for all the leaves measured.

Dry weight of leaves.

	Area 8	Area 45/47	Area 49	Singlo East.	Totals.
5th leaf Shaded ...	181	296	58	54	589
Unshaded ...	166	265	57	43	531
3rd leaf Shaded ...	105	185	24	30	344
Unshaded ...	100	182	23	28	333

Area of leaves.

	Area 8	Area 45/47	Area 49.	Singlo East	Totals.
5th leaf Shaded ...	34,826	42,036	11,998	10,276	99,136
Unshaded ...	24,820	30,131	9,672	6,483	72,106
3rd leaf Shaded ...	22,790	28,376	4,827	5,911	61,904
Unshaded ...	18,241	23,516	3,968	4,346	50,071

The Ratio $\frac{\text{area}}{\text{dry wt.}}$ of leaves.

	Area 45/47	Singlo East.
5th leaf Shaded ...	2,544	568
Unshaded ...	2,057	455
3rd leaf Shaded ...	2,727	596
Unshaded ...	2,340	464

As can be seen from the above tables, shade causes an increase in both leaf area and dry-weight ($P < .001$ in both cases), and an increase in the ratio $\frac{\text{area}}{\text{dry wt.}}$ ($P = .02$—$.01$).

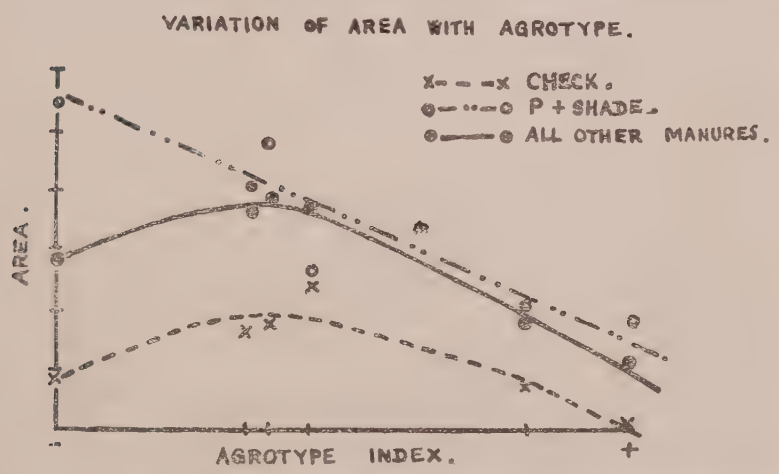
Shade is also effective in increasing the rate at which the areas and dry-weights increase with age of the leaf, and in decreasing the rate of decrease in their ratio. In these respects, manurial treatments appear to have greater differential

effects than in the case of the absolute measurements. These figures are given below.

	Check.	Shade	Nitrogen	Nitrogen+ Shade	Phosphate	Phosphate+ shade.
%Increase in area ...	31	63	26	40	28	44
%Increase in dry wt. ...	47	65	47	57	46	56
%Decrease in $\frac{\text{area}}{\text{dry wt.}}$ ...	10.1	-0.05	14.0	11.3	12.0	7.4

These figures are in respect of average agrotypes ; there are no significant differences between agrotypes. However, different agrotypes show differing responses to treatments when leaves of the same age are considered. The graph for leaf area is given in fig. 1 ; dry-weight gives an almost identical curve.

FIG. 1.



All the treatments cause an increase in leaf area (and dry-weight) over check; there are no significant differences between the effects of these treatments except in the case of the application of phosphate under shade, which is unique in appearing to be a linear function of agrotype index.

Effect of Phosphate.

Under full sun, the yield possible with phosphate is less than that possible with nitrogen, but under shade the same yield has been obtained by the correct application of either manure. This is true for 50% shade, but may not necessarily be true for other light intensities, and, moreover, the effect was only observed during the first year of application. The response to phosphate was found to hold even when nitrogenous manuring had been carried out previously.

Thus at 50% shade, phosphate and nitrogen are exactly equivalent.

These are average equivalences for mixed populations, and need not necessarily hold for a pure population such as a vegetative clone.

It might be possible to relate the balance of applied manures to the balance, within the plant, of chemicals derived from these manures. This has been established for the oil palm, where it was found that the balance of potash and phosphate in the tissues determined the manurial requirements of the plant.

The balance of these compounds, expressed as a percentage of the dry-weight of the lamina, was thus examined for the tea plant, and compared with the phloem index. Results suggest that the ratio $\frac{K_2O}{P_2O_5}$ will show a linear correlation with phloem index.

Agrotype Index—

The agrotype index (Ai) in relation to anatomy.

The agrotype concept was originated by Gregor (1933)* and applied by this department to the hybrid swarms of tea found in cultivation. In tea, the agrotype index of a population is based upon the occurrence of four distinct types which can readily be distinguished from each other by patina and pose of the leaf. For the purposes of this report it is proposed to call these four types simply A, B, C, and D; it must be noted, however, that this is only a temporary terminology.

*GREGOR, J. W. (1933). The Ecotype Concept in Relation to the Registration of Experimental Plants. Ann. App. Biol. XX(2): 213.

The four types of tea plant can be recognised by the following key :—

Leaf surface matt.....A

Leaf surface glossy

Leaves erect.....B

Leaves intermediate.....C

Leaves dependent.....D

Tea populations can also be graded on the basis of a count of the total phloem, estimated as the total number of sieve tubes and companion cells per unit cross-section area of petiole.

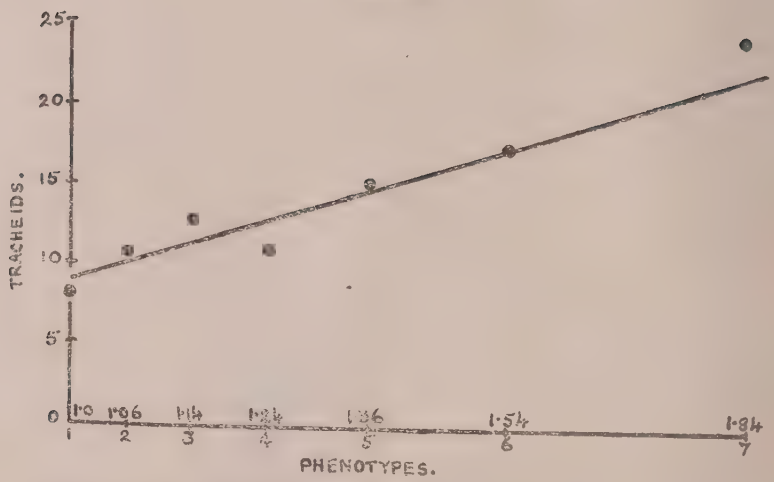
The following table shows the classification of a population of 180 plants, which was carried out independently by different workers on (x) leaf patina and pose, and (y) according to the phloem count.

	x	y
A	12	13
B	14	14
C	151	144
D	3	9

This close agreement confirms the conclusion, reached in previous years, that the characters used in the determination of agrotype indices are natural, and have a fundamental basis in the hereditary system of the plants.

When the phenotypes, subjectively chosen and using the same characters as are used to determine Ai, are arranged at unit intervals, it is found that linear relationships exist between the Ai and the number of phloem cells, the number of tracheids, and the ratio of phloem cells to tracheids. One of these relationships is illustrated in figure 2.

FIG. 2.



The seven phenotypes shown in fig. 2 are arbitrary interpolations along a gradient from dependent leaves to erect leaves and continuing by way of increasing mattiness. The subjective nature of these phenotypes necessitates their being called 1, 2, 3, etc.

The above relationships suggest that the phenotypic groups are related genetically. This is supported by breeding experience, which indicates that the tea grown in Assam is derived mainly from two parental types, designated as var. *sinensis* and var. *assamica*, which differ in several characters. Although it is possible that other introgressions have occurred, the two characters used in the determination of agrotype indices appear to be derived solely from these two varieties.

The fact that the number of phloem cells can be correlated both with phenotypes and with agrotype index suggests that the phloem is of primary importance in the genetical interpretation of growth. This is supported by the known importance of the phloem in the translocation of foodstuffs within the plant, and the known relationships between nutrient supply and agrotype index.

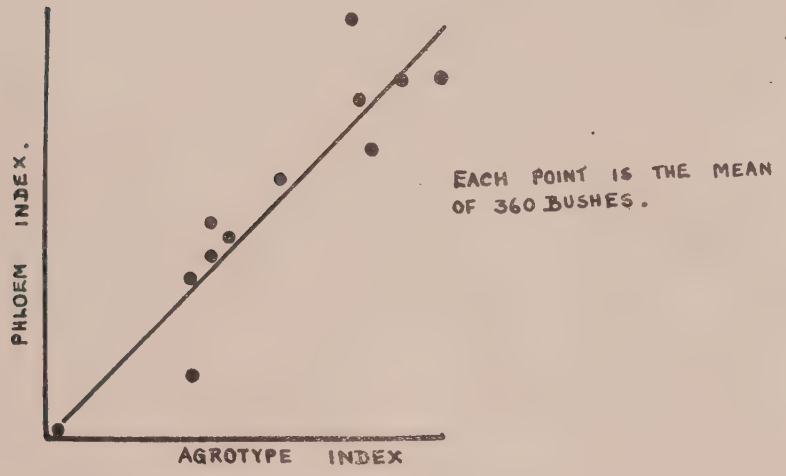
It is thus of interest to note that when the number of phloem cells is plotted against Ai, the slope of the resultant graph is identical with that produced by plotting mature plant size against Ai. This implies that there is a direct relationship

between the number of phloem cells and ultimate plant size; this deduction could be of great importance in breeding programmes where plant size is a basis of selection.

Phloem index (Pi).

Phloem indices are based on a count of the calcium oxalate crystals in the phloem, seen in a transverse section of petiole. This index is constant within a plant on leaves of comparable development. It is found that the average Pi of a population of plants is linearly correlated with the agrotype index of that population. This relationship is shown in Fig. 3.

FIG. 3.



The agrotype indices used in the construction of Fig. 3 are derived from mixed populations of tea, so that no extreme indices are found. These latter can be obtained by using pure phenotypes, as a result of which the agrotype scale can be extended. The incorporation of these extreme indices indicates that the relationship between Ai and Pi is more truly curvilinear, though within the limits of commonly found tea populations a linear representation is sufficiently accurate.

Quality.—***Hair, and its relation to other attributes of tea.***—Detailed experiments show that the average amount of hair, on the under-surface of the leaf, is related to agrotype index, with a correlation coefficient in the order of—0.9. This relationship is not altered by different treatments.

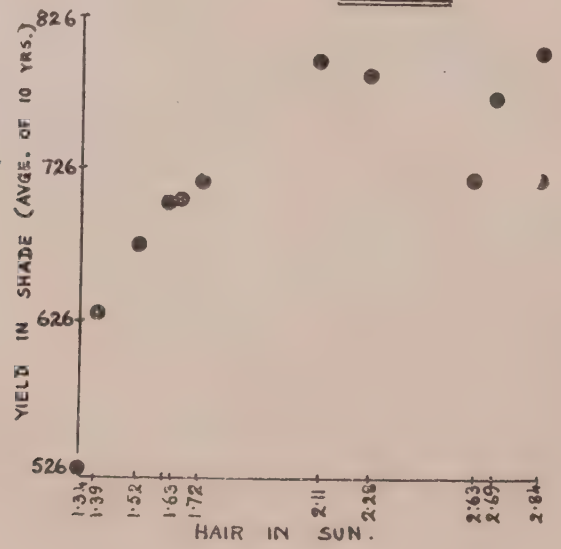
Data from 27 plants show that high values of hair index, stem weight, and the ratio $\frac{\text{stem weight}}{\text{leaf weight}}$ occur on bushes of extreme (high or low) quality. Low values of these factors are associated with medium quality only.

Hair can be related to the ratio of tracheids to vessels, found from a count of these elements in a cross-section of petiole. The resultant linear correlation may be positive or negative, depending upon whether one considers plants commonly cultivated in 1917, or those cultivated in 1937. It appears that modern tea populations have a greater proportion of vessels than those tea plants cultivated 30 years ago, perhaps due to selection for hair.

Further data show that the xylem density, being the summed total of vessels and tracheids in a cross-section of petiole, is positively correlated with hair. Thus quality can be measured both by hair and by xylem density. High quality is associated with both high stem weight and density of wood in the leaf.

Data from 12 *jats* show that, in sun, no relationship exists between hair and yield, but under shade increasing hair is associated with increasing yield. Analysis of these data shows that selection for an increase in hair rapidly leads to a population which will show a great increase in yield under shade. This is illustrated by figure 4.

FIG. 4.



One attribute of yield is the dry-weight of the stem on the plucked shoot. This increases with shade, and the percentage increase in dry-weight of stem due to shade is directly correlated with Ai, so that a large increase in dry-weight goes with the most negative agrotypes, and small increases with positive agrotypes. Since the initial (sun) amount of stem is small, this does not imply that shade will spoil the made tea by causing it to include much woody stem; the amount of stem in shade will still be only a small fraction of the total.

Observations made concurrently with those referred to above, show that median agrotypes have a high response to shade alone, and under correct shade would probably not require the use of sulphate of ammonia. Moreover, they are the agrotypes of the highest quality. These factors go concurrently with the greatest proportion of stem to leaf. Thus the best tea plants have the most stem.

On the best *jats*, the percentage of stem in the made tea is increased by shade from 24% to 30%. Inferior *jats* would not be expected to give as large an increase as this 6%. It can thus be stated that over a period of years, the median agrotypes in our experimental plots have had the amount of stem increased by only 6%, whilst the total yield has about doubled. This is due solely to shade, and, moreover, has occurred in quality tea bushes.

Hair has also been related to the ratio of phloem to xylem. Thus quality is not only correlated with the total vascular bundle, but also with the differential partition of growth which occurs within the bundle.

This knowledge, and all the other relationships referred to in this report, may later enable estimations of yield and quality to be made from a knowledge of the growth of the plant. The fact that most of these factors have already been related to agrotype index may give us further insight into the origins of tea, and act as a guide for future breeding and selection.

BIOCHEMICAL BRANCH.

Staff.—D. J. Wood, B.A., Senior Biochemist, N. B. Chanda, M.Sc., Ph.D., Biochemist.

Dr. N. B. Chanda, joined the Station in April as Biochemist to fill the appointment which was left vacant on the resignation of Dr. E. A. H. Roberts. Mr. S. Chakraborty, M.Sc., joined the Department in August as Assistant, (Senior Grade), to replace Mr. S. N. Sarma who left to take up his duties as Agricultural Analyst attached to the Agricultural Branch.

Advisory and Publications.—During the year 73 memoranda and advisory letters were issued. One Encyclopaedia Serial was revised and minor corrections were made to a number of others prior to reprinting. A paper entitled "Separation of Tea Polyphenols on Paper Chromatograms" by E. A. H. Roberts and D. J. Wood appeared in the Biochemical Journal Vol. 53.

Touring.—The Senior Biochemist visited the T. R. I., Ceylon, at the end of March. The tour included visits to three Ceylon estates. On his return from Ceylon the Senior Biochemist attended a meeting of the Society of Biological Chemists at Bangalore and read a short paper on tea polyphenols. In September a short tour was undertaken in Eastern Dooars where eleven gardens in the Kalchini Circle were visited. Visits were also paid to a few gardens in the Jorhat Circle.

FUNDAMENTAL RESEARCH.

1. The Volatile Constituents of Tea.—*(a) Chemistry*—Work under this head has been largely exploratory in nature in an attempt to develop suitable methods for the separation and identification of the volatile substances from comparatively small amounts of material. It will necessarily be some time before results of any practical value can be reported.

Early in the year it was shown that the aldehydes and or ketones present in a steam distillate of tea could be separated on a one-way paper chromatogram in the form of their 2 : 4-dinitrophenylhydrazones. Petrol ether containing 5%

diethyl ether was found to be a suitable solvent and resulted in the separation of up to seven hydrazone spots (identity unknown). In these experiments 100 gm. of tea or dried leaf was a sufficient quantity for the original steam distillation. Later on attention shifted away from dinitrophenylhydrazine as a reagent following a report in the literature that its derivatives were apt to exhibit polymorphism ; this would mean that a single aldehyde could give rise to two or more spots on a chromatogram instead of one only. As an alternative reagent the use of dimedone (dimethyldihydroresorcinol) was considered, since polymorphism has not been reported among its derivatives. To date the dimedone derivatives of six known aldehydes have been prepared, and a large number of solvents have been tested for their ability to separate these derivatives on a paper chromatogram. Water-saturated petrol ether and 40% aqueous pyridine are two solvents which appear promising. One advantage of dimedone is that it will react with a dilute ethereal solution of an aldehyde to form a crystalline product.

Alcohols, together with aldehydes, apparently form the bulk of the volatile matter in tea leaf, and preliminary work on characterisation by way of their 3:5-dinitrobenzoates has been started. Reaction between alcohols and the acid chloride has been found possible in dilute ethereal solution, and derivatives of four known alcohols have been prepared. So far no suitable solvent has been found for their chromatographic separation.

Working with actual tea extracts it was found that clones with China characteristics gave an ether extract which, on evaporation to dryness, yielded a quantity of crystalline material in addition to the usual brownish syrupy liquid. From visual examination there appeared to be more than one type of crystal. Chromatograms were run of a solution of these crystals, separated as far as possible from the mother liquor, and spraying with ammoniacal silver nitrate revealed two spots, one intense black and the other brown. Both spots on spraying gave immediate reduction in the cold, suggesting an aldehyde nature. The amount of crystalline material obtained was insufficient for a detailed examination. Clones of Assam type without any China characters when treated similarly gave either no crystals or an exceedingly small amount.

Throughout the season extracts were made of certain selected clones, combining those from the same clone in order to give a reasonable quantity of material for chemical analysis. Samples of tea from the Darjeeling district were also extracted and await examination.

(b) Sensory Tests.—It has been found that when a concentrated ether extract of made tea is passed through a column of alumina, successive fractions of the eluate have strikingly different aromas after evaporation of the ether. The fractions produced in this way from a Darjeeling tea were collected and evaporated in tasting cups. Identical taster's infusions of an Assam tea were then added to the cups and the mixture in each cup tasted. Two separate fractions of the ether extract gave to the tea a very fine flavour, while one produced a most unpleasent character ; the other three had comparatively slight effects. From this it would appear possible to fractionate the aroma of tea into its components, as judged by sensory methods. By combining this technique with a suitable chemical method it should be possible to determine the chemical nature of individual fractions and to decide which substances produce desirable flavours.

The Tea Taster's reactions to three volatile chemicals, which have from time to time been reported as occurring in tea, have been tested. The substances are phenylethyl alcohol, citronellol and hexenol (***cis***-n-hex-3-en-1-ol), the first two donated by Messrs. A. Boake, Roberts and Co., Ltd., and the last by Dr. S. H. Harper. Varying amounts of each one were added to a series of tea infusions and these compared with an infusion to which no addition had been made. In small amounts all three produced a rawness, which when only just detectable might be described as briskness. In slightly larger quantity the aroma of the substances could be noticed, hexenol producing an effect similar to that of unripe green apples. The aromas were totally different from the natural aroma of tea, which shows that these substances can form no more than a very small part of the blend which is responsible for tea flavour and aroma.

2. Chemical Changes in Withering.—In the last two Annual Reports data have been given concerning the increase in free amino-acids which occurs during withering due to protein

breakdown. Information has this year been obtained concerning other chemical changes which accompany the withering process.

Early in 1953 examination of black tea samples kept from the Delayed Wither experiment (described in the last Annual Report) showed that a prolonged wither resulted in increased condensation. Figures for Condensation Index (average of nine dates of manufacture) are as follows :

Normal Wither (18 hours).	Delayed Wither (42 hours).
56·5	66·6

Later this was confirmed by examination of samples from the Duration of Withering experiment (described in detail later in this Report). Condensation Index figures for the four durations of withering are as follows :

6 hrs.	18 hrs.	30 hrs.	42 hrs.
33·0	30·1	42·0	44·3

It should be explained that two lots of leaf were used in this experiment—one portion plucked in the morning for the 6 hr. and 30 hr. treatments and another portion plucked in the afternoon for the 18 hr. and 42 hr. treatments. The afternoon leaf was poorer in total "tannin" than the morning leaf : had the two been equal in tannin content the Condensation Index figures of the 18 hr. and 42 hr. samples would have been higher. However the figures as they stand show that prolonging the wither either from 6 hrs. to 30 hrs. or from 18 hrs. to 42 hrs. causes additional condensation in the made teas. This is an important observation, and goes some way to explaining the differences in liquor of the four teas.

Hitherto the factors which have been shown to affect the degree of condensation are time and temperature of fermentation, the activity of the enzyme, and the total amount of tea "tannin" present in the fresh leaf. It is also likely that moisture content will have some effect by determining the concentration of the reacting substances. In the Duration of Withering experiment differences of condensation cannot have been due to any of these factors, because (1) fermentation conditions for

each pair of teas were the same for the shorter wither as for the longer wither, and the residual oxygen uptake of the four teas was the same, (2) the activity of the enzyme was not affected by length of wither, (3) the "tannin" content of the leaf was not affected by length of wither, (4) the moisture content of the withered leaf was approximately the same in all four cases. It seems almost certain, therefore, that the observed differences in condensation result from variations in the duration of withering.

The way in which withering affects subsequent condensation is not, however, obvious. Condensation depends on prior oxidation of the catechins, and so no condensation can occur during the withering process itself ; the relation between withering and condensation must be an indirect one.

The first explanation considered was that the level of free amino-acids in the withered leaf, which increases as the wither is prolonged, might influence the condensation of oxidised catechins. This possibility was supported by a Russian claim that pigment formation during *in vitro* oxidation of catechins by a tea oxidase preparation was accelerated in the presence of amino-acids. Similar experiments have been performed by us in a number of different ways, but so far we have been unable to show any effect of amino-acids on either pigment formation or condensation.

Later, during an examination of nitrogen fractions in samples from the Duration of Withering experiment, an apparent increase in caffeine due to withering was found. This very surprising result was obtained on every date that the experiment was performed, figures for caffeine content in made tea, in withered leaf after drying and in withered leaf before drying being essentially similar. Typical figures are as follows :—

	Withered Leaf, Undried.	Withered Leaf Dried.	Made Tea.
6 hrs.	3.80	3.92	3.93
18 hrs.	4.01	4.06	4.25
30 hrs.	4.26	4.59	4.65
42 hrs.	4.56	4.74	4.83

At first sight it seemed so unlikely that caffeine could actually increase during withering, even though little is known of its biosynthesis, that it was assumed our method of analysis was at fault. Numerous experiments were therefore performed in order to detect the source of error, paying particular attention to the degree of extraction of caffeine from the sample and the purity of the extracted product; however no error could be found. Comparing our standard method (in which caffeine is calculated from the nitrogen content of the extracted product) with the alternative method of direct weighment and also with a Soxhlet extraction method it was found that in all three cases the figures told the same story. A lot more work requires to be done before we can be certain of the explanation of these figures. One possibility is that part of the caffeine in tea leaf is somehow combined in a form which renders it insoluble, and that this combination product gradually breaks down as withering proceeds. But whatever the explanation, it would appear from the above figures that the amount of free caffeine does actually increase during withering, and that the quantity present in an infusion of tea prepared for drinking purposes is greater following a prolonged wither than it is after a short wither.

Following these findings on the behaviour of caffeine during withering a study was started of the effect of caffeine on the condensation of catechins. Using the Warburg respirometer and with a system consisting of soluble oxidase preparation and *d*-catechin it is found that the presence of caffeine leads to an increase in oxygen consumption and a very substantial increase in condensation (in one experiment the latter being doubled in the presence of caffeine). It is also found that in the method for estimation of Condensation Index the substances precipitated by 1% sulphuric acid contain some 7% of caffeine. Although there is as yet no direct proof that in fermenting leaf caffeine has this same effect of influencing condensation, it is reasonable to assume from all the evidence obtained this year that it does so. The behaviour of caffeine and other purines in model systems is being further studied, and every possible aspect of the subject will be investigated, including the effect of caffeine on individual oxidation products and polymer fractions.

Summing up this year's work on the chemistry of withering, it is clear that caffeine is involved in pronounced chemical

changes, so far undetermined, which lead to a progressive increase in free caffeine as withering proceeds. The amount of caffeine apparently influences the extent of condensation of oxidised catechins which is found to be greatest after a long period of withering. Differences in the extent of condensation are partly responsible for determining the characteristic liquoring properties of teas withered for different lengths of time.

MANUFACTURE.

1. Experimental Withering Chamber.—(*a*) *Physical Aspects of Withering.*

A large amount of data has been accumulated concerning the effect on rate of withering of different combinations of temperature, humidity and air speed.

With finely plucked leaf spread at 1 – 1½ lb. per sq. yd., and using only moderate air speeds (100 – 125 ft. per min.) it is possible to obtain 30% loss in weight in 16 hrs. with a hygrometric difference of as little as 2°F. (A loss in weight of 30% is normally referred to as a "70% wither"; hygrometric difference is the difference between dry bulb and wet bulb temperatures, and for some purposes is a more convenient means of expressing humidity than is % R. H.). It should be emphasised that this figure of 2° hygrometric difference is an average of the incoming and outgoing air. Where the same air has to pass over several successive racks of leaf the hygrometric difference of the outgoing air (and hence its withering capacity) will be less than that of the incoming air because of the moisture picked up during its passage over the leaf. At low air speeds the decrease in hygrometric difference is much more marked than at high air speeds. Some idea of what it means in actual rates of withering is given by the following figures obtained on different occasions in the experimental chamber, where air passes over two or three successive banks of trays, each bank being 2 ft. 6 in. in width.

Air Speed	Average Hygr. Difference	Duration	Percentage loss in weight of leaf		
			1st. Bank.	2nd Bank	3rd. Bank
50 ft./min.	2·5°	16 hrs.	47·2%	37·0%	26·8%
60 ft./min.	3·0°	16 hrs.	49·7%	41·9%	...
125 ft./min.	2·0°	18 hrs.	43·0%	37·2%	31·6%
180 ft./min.	12·0°	3 hrs.	32·8%	29·6%	...
300 ft./min.	6·5°	3 hrs.	33·5%	30·6%	...

The difference in weight of successive banks shows that in a travel of only 2 ft. 6 in. air can pick up sufficient moisture from the leaf to have an appreciable effect on its withering capacity.

Under conditions of high air speed and fairly low humidity a 70% wither can be obtained in 3 hrs. or less at normal thickness of spread. Atmospheric conditions were often such that leaf could be withered in 3 hrs. by drawing outside air through the chamber without the use of any heat. On one occasion leaf was withered to 70% of its original weight in 90 minutes by employing an air speed of about 400 ft. per min., a dry bulb temperature of 100°F. and a hygrometric difference of 12·5°. With leaf spread at the normal thickness raising the temperature causes a slight but definite increase in rate of withering, all other conditions being equal; for instance a hygrometric difference of 5° at 100° causes rather faster withering than the same difference at 80°, air speed being the same in both cases.

At fast air speeds (200 ft. per min. or more) decreasing the vertical interval between trays from 3 in. to 2 in. has no effect on the rate of withering, while being more economical of space. The trays on one side of the chamber have now been altered to a 2 in. spacing. The thickness at which leaf is spread has an effect which is shown by the following figures taken from one particular experiment:

Thickness	Loss in Weight
1½ lb. per sq. yd.	31.0%
2 lb. per sq. yd.	26.6%
3 lb. per sq. yd.	23·0%
3½ lb. per sq. yd.	22·6%

Although thicker spreadings results in a slower wither, as would be expected, the rate of withering is by no means proportional to the increased thickness, and provided the wither is not excessively uneven it would appear economic to spread at 3½ lb. per sq. yd. At this thickness fresh leaf fills the 2 in. space between the trays and air has to force its way between the shoots; as withering proceeds the leaf settles down until finally a space of about 1 in. is left over the leaf on each tray. Under such conditions of thick spreading, close spacing and high air speed the following approximate rule is found to apply:

Rate of loss of weight = X% per hour
where X is the average hygrometric difference in degrees Fahrenheit of the air passing over the leaf.

The surface on which the leaf is spread has some effect on the rate of withering. Under the same conditions of high air speed and thick spreading as above, leaf on hessian cloth, "Tygan" plastic mesh and plain aluminium sheet withers some 5—10% more slowly than leaf on the perforated galvanized sheets with which the chamber is equipped, while leaf on ½ in. wire mesh withers some 5—10% faster.

The average size and texture of the leaf and also the standard of plucking affect the rate of withering. While actual figures vary considerably it may be said in general that shoots from small-leaved bushes wither more rapidly than shoots from large-leaved bushes, finely plucked shoots wither more rapidly than coarsely plucked shoots, and individual clones wither at rates which suggest that leaf texture as well as leaf size is a factor of importance. Leaf which is at all damaged in plucking or transport withers more rapidly than undamaged leaf, and leaf stored for a period to allow chemical changes to occur before withering gives up its moisture more readily than fresh leaf.

(b) Duration of Withering.—The results obtained in the experimental chamber suggest that it will be possible to devise a commercial installation which will wither leaf to the required degree in 3-4 hours. Such a possibility at once raises the question of the effect which a very short wither of this nature will have on liquoring properties, since experiments conducted in recent years indicate that the time interval in normal wither-

ing is an important factor in determining liquor characters. To make the experiment as comprehensive as possible four different durations were compared, with a view to establishing if possible the principles underlying the relationship between duration of wither and liquoring properties. Since chemical changes start as soon as the leaf is plucked and continue whether or not the leaf is physically withered, the duration of withering in the present instance was measured from the time of plucking to the start of rolling and so included the entire period for which the leaf was off the bush prior to manufacture.

The following durations were given :

I. 6 hrs.

II. 18 hrs.

III. 30 hrs.

IV. 42 hrs.

Owing to the difficulties of conducting night manufacture at Tocklai it was not possible to give all four treatments to the same bulk of leaf. Instead, two adjacent blocks from the same Area at Borbhetta were chosen (Area 40, Blocks 2 and 3), each planted with the same *jat* and receiving the same cultural treatment. The following table shows how the totals given above were made up :

Block.	Time Plucked.	Length of Time for Transport & Spreading.	Storage prior to Withering	Length of Time in Chamber.	Total.
2	9.30 a. m.	1 hr.	Nil.	5 hrs.	6 hrs.
2	9.30 a. m.	1 hr.	24 hrs.	5 hrs.	30 hrs.
3	3.30 p. m.	1 hr.	Nil.	17 hrs.	18 hrs.
3	3.30 p. m.	1 hr.	24 hrs.	17 hrs.	42 hrs.

Morning leaf from Block 2 was given a rapid wither using a high fan speed, half of it immediately on receipt and half after 24 hrs. storage, resulting in total durations of 6 hrs. and 30 hrs. respectively. Afternoon leaf from Block 3 was given a slow overnight wither at reduced fan speed, half of it immediately on receipt and half after 24 hrs. storage, resulting in total durations of 18 hrs. and 42 hrs. respectively. Because of the differences in leaf origin, time of plucking and conditions in the withering chamber it is only correct to compare treatment I (6 hrs.) with treatment III (30 hrs.), and treatment II (18 hrs.) with treatment IV (42 hrs.). When making other comparisons it should be remembered that differences may not be entirely due to the duration of withering.

The amount of fresh leaf taken for each treatment was 25 lb., and conditions in the withering chamber were so adjusted that the percentage wither (i.e. loss of moisture) was the same in all four treatments.

Two series of experiments employing the above withering treatments were carried out. In the first (Series A), performed on six occasions from the 30th. June to the 8th. September, leaf from all four treatments was manufactured identically in respect of rolling, fermentation, firing and sorting, the total length of fermentation being 3 hrs. Sorting was carried out to give a single bulk grade from each tea, samples of which were submitted to the Tocklai Taster and two outside Tasters. These samples bore code numbers, and no information was given other than a general idea of the nature of the experiment.

Reports were submitted on the Tocklai tasting form ; these were converted into marks on a scale of 0 to 100 for each character separately. The tables below show the average marks given by each Taster, and the combined average of all Tasters, to individual leaf and liquor characters. Valuations are nominal, for purposes of comparison between the four treatments. Tasters were also asked to give remarks concerning the liquors, taking particular note of any brassy character (suggestive of too short a wither) or any sourness (suggestive of an over-prolonged wither).

Series A.

	TASTER A.					TASTER B.				
	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.
Infused Leaf ...	69	48	58	27	16	58	52	64	58	26
Colour ...	33	42	71	96	14	37	37	67	92	33
Strength ...	21	37	71	96	11	29	37	75	92	29
Quality ...	50	62	54	4	22	42	54	92	79	35
Briskness ...	92	58	50	12	26	46	54	92	79	32
Valuation ...	1/13/10	1/14/3	1/14/9	1/11/0	0/1/0	2/6/8	2/7/2	2/8/3	2/8/2	0/0/11

	TASTER C.					AVERAGE OF ALL TASTERS.				
	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.
Infused Leaf ...	75	44	56	37	15	67	48	60	41	12
Colour ...	29	42	54	75	32	33	40	64	88	15
Strength ...	33	25	50	54	26	28	33	65	81	12
Quality ...	50	29	50	25	17	47	49	65	36	18
Briskness ...	71	46	71	42	44	69	53	71	44	20
Valuation ...	2/0/7	1/15/11	2/1/2	2/0/10	0/1/8	2/1/8	2/1/9	2/2/9	2/1/5	0/0/8

S. D.—the difference required for significance at the 5% level.

All three Tasters agree that extending the period of withering either from 6 hrs. to 30 hrs. or from 18 hrs. to 42 hrs. causes an increase in colour and strength, the difference for each character being highly significant. As regards the effect on quality and briskness opinions differ. Taster A finds no appreciable difference in quality between the first three teas but a big reduction in quality on extending the wither to 42 hrs. Briskness he considers to fall off progressively as the duration of withering is increased. Taster B in striking contrast finds that both quality and briskness improve at the longer durations. Taster C finds a difference only between the teas originating from Block 2 and those from Block 3. Infused leaf is adversely affected by prolonging the wither according to two Tasters, but not according to the third. In valuation all three Tasters place the 30 hr. tea first in order of preference, and it works out significantly better than the 6 hr. tea. The relative value of the 18 hr. and 42 hr. teas is the subject of marked disagreement; Taster A very much prefers the former. Taster B prefers the latter, Taster C appears to prefer the latter although the difference is not significant.

The remarks made by Taster A were very consistent from week to week. On every occasion he picked out the 6 hr. sample as being thin, grassy, or having an unwithered character, and the 42 hr. sample as being heavy, dirty and on one occasion sourish. Taster B did not detect either a brassy or a sour taste in any of the samples. Twice he mentioned the 30 hr. and 42 hr. samples as being superior in briskness, and once he mentioned the 6 hr. and 18 hr. samples as lacking briskness. Taster C picked out the 6 hr. tea twice as being light and metallic, and on two other occasions the 18 hr. tea as having a trace of brassiness. Twice he indicated a distinct preference for the 42 hr. tea, describing it as round and mellow, or superior in body and strength; on another occasion he found it rather soft.

While it is not intended in this section to give full details of chemical analysis for these teas, figures for Condensation Index are included because they have an important bearing on the tasting results. Average figures for Condensation Index over the whole experiment are as follows:

6 hrs.	18 hrs.	30 hrs.	42 hrs.
33.0	30.1	42.0	44.3

Prolonging the wither causes an increase in the extent of condensation. It has been shown by Roberts (Biochem. J. 45, 538, 1949) that a similar increase in condensation accompanies fermentation, and the way in which liquor characters are related to length of fermentation is given in Tea Encyclopaedia Serial No. 56. Combining the two the relation between Condensation Index and individual liquor characters may be plotted, and when this is done it will be seen that over the approximate range covered by the present experiment an increase in colour and strength is accompanied by a fall in briskness and quality. A similar trend might be expected in the present instance, but in fact Taster A is the only one of the three to report such a trend.

After the experiment in its original form had been performed six times, the figures for Condensation Index quoted above, together with the reports received from Taster A, suggested that the differences between samples due to duration of withering might be evened out by manipulating the time of fermentation. Accordingly a second series of experiments (Series B) was conducted on four occasions from the 22nd. September to the 13th. October, varying the fermentation according to the length of wither as shown in the following table :

Duration of Wither.	Length of Fermentation.
6 hrs.	3¾ hrs.
18 hrs.	3¼ hrs.
30 hrs.	2¾ hrs.
42 hrs.	2¼ hrs.

The object was to produce four teas of similar Condensation Index and colour, and then to see whether they would also be similar in other respects. Samples were submitted as before to the same three Tasters, whose results are tabulated below :

Series B.

	TASTER A.					TASTER B.				
	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.
Infused Leaf ...	56	43	59	25	19	56	49	75	43	39
Colour ...	69	62	75	62	19	75	62	75	69	53
Strength ...	37	69	87	69	23	56	62	75	81	63
Quality ...	44	56	62	25	37	56	56	81	81	55
Briskness ...	87	56	69	37	37	50	56	81	81	60
Valuation ...	1/12/4	1/14/-	1/15/-	1/12/5	-/1/9	2/7/1	2/7/4	2/8/5	2/7/10	/3

	TASTER C.					AVERAGE OF ALL TASTERS.				
	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.	6 hrs.	18 hrs.	30 hrs.	42 hrs.	S. D.
Infused Leaf ...	72	53	53	25	16	61	49	62	31	14
Colour ...	56	44	56	44	34	67	56	69	58	22
Strength ...	56	56	50	31	48	50	62	71	60	22
Quality ...	69	44	50	25	45	56	52	65	44	22
Briskness ...	56	31	50	25	55	65	48	67	48	23
Valuation ...	2/3/9	2/2/3	2/2/3	2/-/-	-/3/-	2/2/4	2/2/5	2/3/2	2/1/7	-/1/-

Measurment of Condensation Index gave the following figures :—

6 hrs.	18 hrs.	30 hrs.	42 hrs.
40.5	37.8	38.6	34.4

The 30 and 42 hr. teas are now slightly less condensed than the 6 hr. and 18 hr. teas respectively ; however in colour there is nothing to choose between them. For the remaining liquor characters, few of the differences are statistically significant, partly due to the small number of repeats and partly due to inconsistent reports. Taster A finds the 30 hr. tea much preferable to the 6 hr. tea in strength, and for this reason more valuable ; the 42 hr. tea he finds equal to the 18 hr. tea in strength, slightly but not significantly worse in both quality and briskness, and lower but not significantly lower in valuation. Taster B appears to find an improvement in strength, quality and briskness as a result of the longer wither, while Taster C appears to hold the opposite view ; in neither case however, are their differences significant. Taster B supports Taster A in valuing the 30 hr. tea higher than the 6 hr. tea. Other differences in valuation given by Taster B and those given by Taster C are not significant, but are in the same direction as their marks for liquor characters.

Taster A's remarks on the liquors of these teas were much the same as his remarks on the Series A teas ; on all four occasions he picked out the 6 hr. sample as being either thin or "green", and the 42 hr. sample as being a little heavy. The essential characteristics of the teas would thus appear to be unaffected by variations in length of fermentation, although a shorter fermentation has improved the liquor of the 42 hr. tea. Taster B remarked twice on the 42 hr. tea and once on the 30 hr. tea as being a little metallic ; on one occasion he found the 18 hr. tea soft and dull. Taster C on different occasions picked out all four teas as being metallic—once he mentioned the 30 hr. and 42 hr. teas as having more body than the other two but being less bright.

On the conclusion of the entire experiment, Series A samples which had been stored in stoppered bottles for a period ranging from 3 to 5 months were submitted to Tasters B and C for re-

tasting, with the object of ascertaining whether any change had occured in the order of preference for the teas as a result of maturing. The key was disclosed at the time of sending the samples, and Tasters were asked to give general remarks and comparative valuations only. Average valuations given by each Taster to the complete set are as follows :

	6 hrs.	18 hrs.	30 hrs.	42 hrs.
Taster B	2/9/10	2/10/5	2/11/2	2/10/4
Taster C	2/3/11	2/3/-	2/2/1	2/1/4

Taster B still prefers the 30 hr. tea to the 6 hr. tea, but finds no appreciable difference between the 18 hr. and 42 hr. teas, the latter having gone down in his estimation as a result of storage. Taster C in contrast now gives a distinct preference to the short wither, and finds any increase over 6 hrs. to be detrimental. From their remarks it would appear that Taster B likes the 30 hr. tea for all round usefulness and the 42 hr. tea for colour while he finds the 6 hr. and 18 hr. teas rather light in cup. Taster C, while commenting that the majority of samples have "gone off", prefers the 6 hr. and 18 hr. teas for quality and briskness ; the 30 hr. and 42 hr. teas, although having more body, are apt to be rather flat with dark coloured liquors.

These contradictions are rather hard to understand. However for the purpose of making recommendations concerning the duration of withering too much importance should not be attached to these particular results ; small samples when stored tend to deteriorate, hence the changes noted in the present instance do not necessarily represent those which would have occured on maturing.

Considering the results of the entire experiment, Taster A's opinions are those which are most consistent among themselves and which best agree with our previous findings on the subject. According to this Taster prolonging the period of withering from 6 hrs. to 42 hrs. causes a progressive increase in colour and strength and progressive decrease in briskness ; quality appears to be improved up to a moderate duration but to fall off rapidly after 30 hrs. withering. Leaf withered for a considerable time makes a better tea if its period of fermenta-

tion is reduced, but the tea resulting from a rapid wither is apparently not improved by extending the fermentation time. Tasters B and C agree with Taster A as regards the improvement in colour and strength due to a longer wither, but their views on quality and briskness differ not only with his but with each other's. From the practical point of view it is important to know whether a rapid wither following immediately after plucking will produce a tea comparable with that resulting from the system in use today or whether it must be accompanied by a period of storage. The differences in valuation between samples in this experiment are not large enough to answer this question with certainty, but it would seem unwise at present to advocate withers of very short duration as the resulting teas might be thin in liquor. The amount of benefit derived from storage of leaf on a commercial scale would probably depend on the state of the leaf as it arrived at the factory, and leaf which had sustained a high degree of damage in plucking or in transport might even give better results if manufactured with the minimum of delay. In the case of leaf which arrives at the factory in good condition the optimum duration of withering (including storage) is likely to vary according to the particular market for which a tea is destined, a fact which might account for the varying preferences shown by different Tasters.

Two points with regard to this experiment need to be stressed. One is that no adequate information has been obtained as to the effect of maturing on teas from different durations of wither; the effect of maturing under strictly commercial conditions is one which will have to be studied. The second point is that the practical implications of experiments of this nature conducted at Tocklai will not necessarily apply in high elevation districts where flavour is of prime importance, and it might well be found that a short wither suited Darjeeling teas. However, no matter what type of leaf or what district is being considered, it can safely be said that the characteristics of a tea are partly determined by the length of wither, which makes a full understanding of the relationship between the two most necessary. The present experiment has added to our knowledge of this subject, and has also indicated the directions in which further investigations should proceed.

(c) Leaf Storage Before or after Withering.—In the last section it was shown that a period of green leaf storage may be necessary in conjunction with rapid withering in order to produce a tea with the usual characteristics. The purpose of the present experiment was to determine whether this leaf storage is better given before or after the withering process.

The details of the experiment were as follows. Morning leaf from Borbhetta, plucked about 9-30 a.m., was divided into two portions. The first portion ("storage after withering") was spread in the experimental chamber and withered straight away in a matter of 3-4 hours. It was then removed from the chamber as carefully as possible, to minimise leaf damage, and stored until 8.30 the following morning in a humid atmosphere at a thickness equivalent to 5 lb. fresh leaf per sq. yd. The second portion ("storage before withering") was stored as above until the first portion had been withered. It was then transferred to the withering chamber where storage continued, with the doors closed and the fan switched off, until midnight. The fan was turned on from midnight until the desired wither had been obtained. At 8-30 a.m. both portions of leaf were weighed, and were then manufactured simultaneously giving the same treatment to both. The total duration of withering plus storage was in each case just short of 24 hours. The teas were sorted to give a bulk grade containing about 80% of the total, samples of which were distributed to three Tasters. The experiment was performed on six occasions from the 4th. August to the 21st. October. The average percentage wither of the two portions of leaf, calculated over the whole experiment, was as follows :

Storage after withering	70·4%
Storage before withering	70·3%

Reports were submitted on the Tocklai Tasting Form and were converted into marks in the usual way. The table below shows the average marks given by each Taster, and the combined average of all Tasters, to individual leaf and liquor

characters. Valuations are nominal, and only for comparison between the two treatments.

	TASTER A.		TASTER B.		TASTER C.	
	Storage after Withering	Storage before Withering	Storage after Withering	Storage before Withering	Storage after Withering	Storage before Withering
Infused leaf ...	75	75	50	67*	60	64
Colour ...	71	79	71	42*	87	54*
Strength ...	75	87	58	62	79	62
Quality ...	71	83	37	58*	50	58
Briskness ...	66	75	37	75**	58	79
Valuation ...	2/8/10	2/9/3	1/15/4	2/-/3	1/14/9	1/14/6

AVERAGE OF ALL TASTERS.

	Storage after Withering	Storage before Withering
Infused Leaf	62	69
Colour	76	58*
Strength	71	71
Quality	53	67
Briskness	54	76*
Valuation	2/2/4	2/2/8

*Significant at 5% level.

**Significant at 1% level.

There is little to choose between the two teas ; combining all three Tasters' opinions the only significant differences are that the leaf stored after withering gives slightly better colour, while that stored before withering gives slightly better briskness. The difference in quality is just short of being significant, but as would be expected is in the same direction as the difference in briskness.

It is however necessary to add a few remarks to the above results by way of explanation, as there are reasons to believe that under actual factory conditions there might well be a big

difference between the two treatments. The utmost care had to be taken when transferring the leaf withered first to the storage cabinet, as this leaf, being flaccid, was very easily damaged, and any damage at this stage caused a certain amount of fermentation during the period of storage, with soft liquors as a result. This was found during preliminary trials before the experiment proper was begun. Even with the most careful handling a small amount of damage could not be avoided, and it is almost certain that the slight differences noticed between the two sets of teas were entirely due to this damage. This opinion is supported by the following figures for Condensation Index, each of which is an average of all six dates of manufacture :

Storage after Withering	46.4
Storage before Withering	38·7

Since the total duration of withering and the length of fermentation were the same in both treatments the most likely explanation of the difference in condensation is that damage occured to the leaf stored after withering and caused it to ferment in patches before manufacture commenced. It is probable that if the leaf had not been handled at all between withering and storage there would have been no detectable difference between the teas. It can safely be said that, under commercial conditions, if the withered leaf had to be man-handled from the withering installation to the place of storage the resulting tea would be poor in liquor by reason of the damage done to the leaf. This indicates that any necessary storage should be given before withering rather than after, except in cases where it is possible to leave the withered leaf totally undisturbed.

(d) Temperature of Withering.—A question which requires to be answered in connection with any form of controlled withering in the plains, whether it is to be a slow overnight process or a rapid batch process, is the effect of air temperature on the resulting teas. It was decided to investigate this effect over a period of about 16 hours, comparing the highest and lowest temperatures of which the machine was capable, i. e. 100°F. and 70°F.

The design of the experiment was as follows. Because the chamber is only able to give one set of conditions at a time the experiment had inevitably to be split over two days each week. Leaf was plucked each Wednesday from Area 15 and each Thursday from Area 15A, two adjacent areas planted with the same *jat* and receiving the same cultural treatment. On each day the leaf was divided into two portions, one half being withered in the chamber and the other being spread in the outside *chung* house to serve as a check. In order to avoid any possible difference due to plots, in the first week leaf from Area 15 was withered at 100° and that from Area 15A at 70° ; the second week the treatments were reversed, and so on alternating throughout the season. The humidity in the chamber was approximately the same for the 70° wither as for the 100° wither, the air speeds being adjusted to give roughly the same loss of weight in each case. Leaf in the *chung* house was spread to give as near as possible the same percentage wither as leaf in the chamber, but owing to fluctuating conditions this aim was not always achieved. On each day leaf from the chamber and from the *chung* house was manufactured simultaneously, the tea from each being sorted to give a bulk grade containing about 80% of the total. Samples of all four teas were each week distributed together to three Tasters. These samples bore code numbers, the order being changed each week. The experiment was performed thirteen times from the 3rd. July to the 23rd. October. Average percentage withers over the whole series were as follows :

Check for 70°	70° Wither	100° Wither	Check for 100°
71.8%	67.0%	64.9%	72.3%

Reports were submitted on the Tocklai Tasting Form, and were converted into marks in the usual way. The table below shows the average marks given by each Taster, and the combined average of all Tasters, to individual leaf and liquor characters. Valuations are nominal, for purposes of comparison between the four treatments.

	TASTER A.					TASTER B.				
	Check for 70°	70° Wither	100° Wither	Check for 100°	S. D.	Check for 70°	70° Wither	100° Wither	Check for100°	S. D.
Infused Leaf	55	62	45	60	16	54	54	41	53	9
Colour	52	56	73	50	23	44	48	63	52	12
Strength	62	69	67	48	23	56	54	71	54	13
Quality	56	67	39	44	24	56	56	35	63	18
Briskness	60	75	58	58	26	71	71	58	69	16
Valuation	1/15/8	2/0/9	1/15/9	1/15/7	0/1/2	1/14/0	1/14/0	1/13/0	1/14/5	0/0/10

	TASTER C.					AVERAGE OF ALL TASTERS.				
	Check for 70°	70° Wither	100° Wither	Check for 100°	S. D.	Check for 70°	70° Wither	100° Wither	Check for 100°	S. D.
Infused Leaf	53	59	54	52	17	54	58	47	55	8
Colour	65	71	65	56	26	54	58	67	53	11
Strength	63	67	67	60	28	60	63	69	54	12
Quality	56	79	69	50	27	56	67	48	53	13
Briskness	56	79	69	50	27	62	75	62	59	13
Valuation	2/7/6	2/8/0	2/7/9	2/7/4	0/0/8	2/1/8	2/2/4	2/1/6	2/1/9	0/0/6

S. D. = the difference required for significance at the 5% level.

The leaf withered at controlled temperature may be compared with its own check ; the two check treatments may be compared with each other, and where the difference between these two is not significant the 70° and 100° treatments may be compared directly with each other. In point of fact the difference between the two check treatments is nowhere significant, so throughout the table it is possible to compare the 70° wither directly with the 100° wither.

Taster A considers the 70° wither to be better than the 100° wither in respect of infused leaf and quality. Other differences are not significant. In valuation a difference of one anna in favour of the 70° wither is not significant. Taster B prefers the 70° wither for infused leaf and quality, and the 100° wither for colour and strength. His difference of one anna in favour of the 70° wither is significant. It is interesting to note that he finds no difference between the 70° wither and its check ; it is the 100° treatment that gains strength and loses quality. Taster C finds no significant differences. The combined opinion of all three Tasters is that the 70° wither is preferable to the 100° wither for infused leaf, quality and briskness, while it is worth 10 pies more. The 100° wither, although better than its own check in colour and strength is not significantly better than the 70° wither.

It is most surprising that a difference of 30° in withering temperature over a period of 16 hours has had so little effect on the teas, and that withering at 100° has not had the adverse results that might have been expected. There were a few individual occasions during the course of the experiment when, according to one or more Tasters, the 70° wither stood out for quality and flavour, or for second flush character, being valued up to 6 annas more than its check ; but on certain other occasions it actually turned out slightly worse than the 100° wither. Taster B several times found an unpleasant undercurrent in the 100° wither, and once valued it 8 annas lower than its check ; however this was apparently not noticed by the other two Tasters.

At the end of November, when it was anticipated that a little Autumnal character might be present in the teas, the experiment was repeated twice more, but using different temperatures from the above. The two treatments in the Chamber were at controlled temperatures of 80-85° and 95°-100°, while the check treatments (natural wither) were at a

temperature of 75° when plucked falling to 55° at night. On both occasions Taster C distinctly preferred the check treatments, once for Autumnal character and once for quality and briskness , Taster A reported no appreciable difference.

There are indications from the above that during flavoury periods, i.e. the second flush and Autumnal seasons, flavour may be conserved by withering at a low temperature. It is possible that in a district such as Darjeeling, where flavour is of paramount importance, the difference between low temperature and high temperature withering might be more than that found in this experiment. Under Assam conditions during the monsoon season, although withering at 100° gives a significantly worse tea than withering at 70° the difference between the two is very slight.

(e) *Miscellaneous Experiments.*—During late October and early November four unreplicated experiments were performed, partly at the request of Mr. D. W. Tull who was then visiting the Station. In all cases the teas were reported on only by the Tocklai Tea Taster. Brief details and results of these experiments were as follows :

(1) 26-10-53.

Treatment I.—Morning leaf was withered at 100° in 2 hours. Total duration 3½ hours.

Treatment II.—Afternoon leaf from the same area was stored overnight spread on trays at 10 lb. per sq. yd. It was then withered at 100° in 2½ hours. Total duration 21 hours.

Treatment III.—Afternoon leaf from the same area was stored exactly as above. It was withered at atmospheric temperature (86°) in 2½ hours immediately after Treatment II had been completed. Total duration 24 hours.

Treatment IV.—Afternoon leaf from the same area was withered overnight in the outside *chung* house. Total duration 24 hours.

The percentage wither was 65% in the case of I, II and III, 56% in the case of IV. Manufacture was the same for all four treat-

ments ; the teas were sorted to give a single bulk grade from each. The Taster's valuations were as follows :

I	II	III	IV
1/13/-	2/-/-	1/15/3	1/14/-

He remarked on I as being grassy and on IV as being slightly heavy on the palate.

(2) 27-10-53.

A single bulk of afternoon leaf was divided into three portions.

Treatment I. Leaf was stored overnight spread on trays at 10 lb. per sq. yd. It was then withered in the chamber at atmospheric temperature ($77^0 - 85^0$) in $2\frac{1}{2}$ hours. Total duration 21 hours.

Treatment II. Leaf was stored exactly as above. It was withered at 100^0 for $2\frac{1}{2}$ hours immediately after Treatment I had been completed. Total duration 24 hours.

Treatment III. Leaf was withered overnight in the outside *chung* house. Total duration 21 hours.

The percentage wither was approximately the same in all cases. The usual standard manufacturing procedure was adopted, sorting to give a bulk grade. The Taster's valuations were as follows :

I	II	III
1/14/-	1/13/6	1/13/-

A slight difference in briskness was noted ; otherwise the liquors were similar.

(3) 28-10-53 and 29-10-53.

The first day's leaf, plucked in the afternoon, was divided into two portions.

Treatment I. One portion was stored overnight at 10 lb. per sq. yd. It was then withered in the chamber for 6 hours at 82° – 84° using a high air speed and fairly high humidity.

Treatment II. The other portion was withered overnight in the *chung* house.

The second day's leaf, plucked in the afternoon, was similarly divided into two portions.

Treatment III. The first portion was stored as for Treatment I. It was then withered in the chamber for 6 hrs. under atmospheric conditions (78° – 83°, medium humidity) at a low air speed.

Treatment IV. The second portion was withered overnight in the *chung* house.

In all cases the total duration was 25 hours; Treatment II was slightly over-withered compared with the others. The Taster's valuations were as follows:

I	II	III	IV
1/15/-	1/14/-	1/15/6	1/13/6

The leaf withered in the chamber was in both cases preferred for strength and quality.

(4) 2-11-53.

Afternoon leaf was divided into three portions.

Treatment 1. One portion was stored overnight in a large plucking basket placed on the factory floor, the depth of leaf being 12 inches. It was then withered in the chamber for 3½ hours at a temperature ranging from 77° to 93°. Total duration 22 hours.

Treatment II. A second portion was stored as above at 12 inches thick. It was withered in the chamber for 2½ hours at 80°-87° as soon as Treatment I had been completed. Total duration 25 hours.

Treatment III. The third portion was withered overnight in the *chung* house. Total duration 25 hours.

The percentage wither of I and II was 75% ; that of III was 68%. All three were manufactured under identical conditions and sorted to give a bulk grade from each. The Taster's valuations were as follows :

I	II	III
1/14/-	1/12/6	1/13/-

Slight differences in colour and strength were noted ; quality and briskness were the same in all three samples.

These experiments show that leaf can be stored at a considerable thickness and then withered very rapidly without having any adverse effect on the liquor ; in fact the leaf so treated gave a tea in most cases slightly preferable to that made from leaf withered in the normal manner. Differences in temperature do not appear to have had any appreciable effect. In all four experiments considerably more first fine *mal* was produced from the stored leaf than from the normally withered leaf. It is hard to say whether under commercial conditions this would be an advantage or not.

It should be emphasised that these four experiments were performed at a time of year when low temperatures were prevailing. During the hot months it would certainly not be possible to store leaf 12 inches thick. This was made clear by storing leaf overnight at this thickness in the chamber with the temperature maintained at 85°. By the morning very considerable reddening had occurred, and the leaf was not fit to manufacture.

2. Survey of Relative Humidity.—Throughout the year figures for wet and dry bulb temperature have been recorded by seven tea estates at the request of T'ocklai. Readings were taken in a Stevenson Screen three times each day. The object

was to compare atmospheric humidities in different districts so that some idea of withering conditions could be obtained. It was not considered necessary to take readings in districts with lower rainfall than Tocklai (average 82 inches per annum), and the estates chosen were in Eastern and Western Dooars, Assam North Bank and Doom Dooma, some of them with an annual rainfall exceeding 150 inches.

Examination of the figures supplied showed that on some estates abnormally high wet bulb temperatures were habitually recorded, and these it is considered must have been due to some error. At Tocklai, for instance, the maximum wet bulb temperature during the year was 84°. a figure which was reached on only five days. One estate in the Western Dooars recorded wet bulb temperatures of 90° or more on eleven occasions, the highest being 95°. Outside opinion is that in N. E. India a true wet bulb temperature of 88° is the absolute maximum possible, and that in the Dooars figures of 86° are very rarely exceeded. In some cases the Stevenson Screen is probably responsible for high wet bulb temperatures. Locally made screens sometimes have the louvres inclined at such a steep angle that hardly any air space is left between them ; on others the coating of white paint, necessary to reflect sunlight, is allowed to wear off. In either case the temperature inside will be higher than the true atmospheric temperature. Another common source of error is a failure to keep the wick of the wet bulb thermometer properly saturated with water.

The tables below show figures for three estates where measurements appear to have been correctly taken in comparison with figures from Tocklai. Hygrometric difference is the difference between dry bulb and wet bulb temperatures.

Eastern Dooars (Rainfall 1953, 144")

	Average 07.30	Hygrometric 13.00	Difference 17.30
March—April	4·2	11·1	8·2
May—June	3·5	6·9	5·8
July—Sept.	3·6	6·2	4·7
Oct.—Nov.	4·7	11·6	4·9

Assam North Bank (*Rainfall 1953, 92"*).

	Average 08.00	Hygrometric 14.30	Difference 17.30
June	4·6	7·4	6·3
July—Sept.	2·1	6·7	4·7
Oct.—Nov.	1·8	10·1	5·1

Doom Dooma

	Average 08.00	Hygrometric 14.00	Difference 16.45
May—June	2·5	7·1	7·1
July—Sept.	1·3	5·0	5·3
Oct.—Nov.	2·2	8·6	7·6

Tocklai (*Rainfall 1953, 79"*).

	Average 03.00	Hygrometric 12.00	Difference 14.00
March—April	2·5	6·8	8·7
May—June	2·8	6·3	7·4
July—Sept.	2·2	5·7	6·6
Oct.—Nov.	1·3	7·3	8·9

These figures show that in all districts there is during the daytime an appreciable hygrometric difference, even during the wettest months of the year, and during these months the humidity does not differ between districts as much as the rainfall figures would lead one to expect. The year was actually rather a dry one for the Eastern Dooars estate which normally measures about 190 inches, and it is possible therefore that the humidity is usually rather higher ; this will be seen in subsequent years.

Humidity is, on average, at a minimum at about 1 p.m. I.S.T., and it is interesting to compare figures from the Eastern Dooars estate taken at 1 p.m. I. S. T. with those measured at Tocklai at 2 p.m. local time (=1 p.m. I. S. T.). The following Table shows average wet and dry bulb temperatures for the three months July—September, and gives some indication of the daily variation in hygrometric difference (H.D.), all temperatures being measured at 1 p.m.

	Dry	Wet	Diff.	No. of days when H. D. is :— 3° or less.	7° or more.	Rainfall July-Sept.
Eastern Dooars	85·8°	79·6°	6·2°	14	34	80″
Tocklai	86·6°	80·0°	6·6°	12	37	35″

Despite the great difference in rainfall the average H. D. is about the same in both cases, and Tocklai actually has a slightly higher average wet bulb temperature. As would be expected the Dooars estate has rather more days of high humidity and rather fewer of low humidity, but the difference is small.

If it is assumed that the humidity figures recorded this year on the Eastern Dooars estate will apply to other districts of similar rainfall, it appears that conditions for controlled or assisted withering worked out at Tocklai will not require to be greatly modified when extended to estates receiving up to 150 inches of rain annually. It is probable, however, that the incidence of surface moisture on the leaf will be higher in the Dooars than at Tocklai, so some allowance will have to be made for that.

The type of withering installation envisaged at Tocklai, where removal of moisture from the leaf is complete in 4 hours, will entail heating of the air to give it increased drying power, except at times when the hygrometric difference of the outside air is adequate (say 10° or more). When air is heated, no matter what its initial humidity, an increase of 10° in dry bulb temperature is accompanied by an increase of 4° in wet bulb temperature. From this it can easily be calculated how great a rise in dry bulb temperature is necessary in order to increase the hygrometric difference to 10° from any given value. Atmospheric conditions are such that a high humidity is always accompanied by a relatively low temperature. Figures from the Eastern Dooars estate show that, over the period July to September, when the hygrometric difference was 1° to 2° the average dry bulb temperature was 79°, and when the hygrometric difference was 9° to 10° the average dry bulb temperature was 91°. Conditions at Tocklai were similar. These and other figures show that, on average, a hygrometric difference of 10° can be obtained at a dry bulb temperature of about 93° during the most humid period of the year. This figure applies not only to midday but also to morning and evening conditions. During the pre-monsoon and post-monsoon season the same hygrometric difference could be obtained at a lower temperature.

PHYSICO-CHEMICAL BRANCH

Staff:—N. G. Gokhale, B. Sc., Senior Physical Chemist.

The Senio · Physical Chemist was on Home leave during the period June-November and during his absence Mr. S. K. Dey, Assistant Chemist, was in charge of the branch.

Advisory work and correspondence : -The following samples were analysed and reported on during the year :

Soil samples	...	...	487
Manure samples (for experiments on gardens)	...	...	18
Others	...	...	14
		Total ...	519

The soil samples were received from tea gardens in connection with selection of nursery sites, suitability of soil in the case of extension areas, and also from sections already under tea which were not doing well or were due for replanting. Suitable advice was given in each case and, where possible, practical methods of treatment were recommended.

In all, 158 reports were issued to tea gardens in connection with their specific problems and in addition 181 advisory letters were written.

Touring—During the period January—May the Senior Physical Chemist visited the following gardens :

	Circle		Number of gardens
Assam Valley	Jorhat	...	2
,,	Dhunseri	...	1
,,	Naharkatiya	...	1
,,	Nazira	...	1
Cachar	Chutla Bheel	...	2
,,	Hailakandy	...	4
,,	Chargola	...	1
,,	Longai	...	3
,,	North Cachar	...	1
	Total	...	16

Publications :—During the year four Serials from the Tea Encyclopadia were re-written.

Soil acidity :—It is well known that for optimum growth of tea one of the essential conditions is that the soil be markedly acid but the exact factors which are responsible are not yet understood fully. It is considered that our present knowledge of the subject is not sufficiently precise and some further work in elucidating the nature of acidity in the case of our tea soils would be useful. The matter is of some considerable practical importance in the case of soils showing pH values on the border line of acidity tolerated by tea.

It is known that pH of water extract alone does not give sufficient information about soil acidity. Great reliance has been placed by this department in the past on the results of the KNO_3 extract tests. The acidity developed on leaching with a neutral salt like potassium nitrate is not however an adequate measure of the total base unsaturation of the soil. Workers in other countries have made use of another determination known as hydrolytic acidity which is the acidity developed on leaching with the salt of a weak acid. A series of leaching agents have been tried out during the year to test their relative efficacies.

Simultaneously attempts have also been made to determine the total B. E. C. and exchangeable hydrogen by using Mehlich's barium chloride-triethanolamine buffer procedures. The degree of base unsaturation is obtained easily from these latter determinations. About 70 soil samples with pH values varying from 4·0 to 7·0 have been examined and it is proposed to continue this investigation further especially in those cases where the soil is under-acid for optimum growth of tea. Some of the values obtained are shown in the following table.

Degree of base saturation of Tea soils by Mehlich's rapid method using BaC12-Triethanolamine buffer.

Sample	% milli-equivalent B.E C. 100 gms. air dry soil A	% milli-equivalent exchangeable hydrogen/100 gms. air dry soil A-B	% milli-equivalent total metal cations /100 gms. air dry soil A-B	% Base saturation or degree of saturation (A-B) 100 × ... ... (A)	pH 1 : 2·5 soil water extract electrometric	pH 1 : 2·5 soil KNO_3 extract (Exchange acidity) electrometrie	Remarks
Pabbojan ...	21·40	11·20	10·20	48	4·37	4·06	
Cinnnamara ...	7·42	4·60	2·82	38	4·78	3·96	
Hattikhira ...	9·46	6·96	2·50	25	4·97	4·03	
Diffloo ...	7·82	5·98	1·84	24	5·21	4·11	
Dalmore ...	19·00	8·10	10·90	57	5·43	4·28	
Behora ...	15·29	9·20	6·09	40	5·57	4·48	
Dhekiajuli ...	19·80	6·80	13·00	66	5·79	4·34	
Halem ...	22·13	7·00	15·13	68	6·03	4·51	
Tyroon ...	13·39	4·00	9·39	70	6·21	5·27	soil under-acid for tea.
Lamabari ...	18·20	4·50	13·70	75	6·75	5·74	
Nangdala ...	9·54	0·60	8·94	94	7·13	5·75	

As an extension of this work it is proposed to determine the exchangeable calcium and aluminium in the soil. It is possible that the essential condition for optimum growth of tea is a certain balance between these two cations.

Long term effects of continuous cropping.—A special investigation has been started to find out what changes are brought about in the soil condition when an area is retained under tea for a considerable period. The cultural practices followed in tea are special and a distinguishing feature is the automatic turn-over of a fair amount of organic matter regularly. Whether the current practices followed in tea are adequate to maintain the fertility of soils indefinitely however remains to be seen. Maintenance of an adequate level of organic matter in the soil is of vital importance if fertility is to be maintained and the position must be watched carefully if continued success of the industry is to be assured. Soil samples are being collected from areas which have carried tea for varying periods and which, as far as possible, are known to have been comparable initially. It is realised that the cultural system adopted in each particular case will have a lot to do with any possible changes in soil condition and this point will be borne in mind.

Effects of organic vs. inorganic manuring on the chemical properties of soils.—The effects of manuring on soil conditions in the case of tea are being studied in further detail. Continuous use of Sulphate of Ammonia is known to make the soil acid but other changes must also be expected in the exchange complex of the soil. In this connection it is interesting to compare the effects of organic vs. inorganic manuring and the experiment which has been going on at Halem T. E. since 1933 was made use of for this investigation. The treatments in this experiment are :

(i) Check.

(ii) Inorganic fertiliser—40 lb. N as S. O. A., 20 lb. P_2O_5 as Superphosphate and 20 lb. K_2O as Muriate of Potash per acre.

(iii) Cattle manure—200 mds. per acre.

There are seven repeats for each treatment, giving 21 sub plots in all. Full details about the experiment i.e. yield, efficiency of manures etc. will be found in the Station's Annual Reports under the heading Advisory Branch, Assam Valley and North Bank. The present discussion is concerned only with the effects of manuring on the exchange complex of the soil.

Samples were obtained last July from all the sub plots and the following tests were carried out on the samples.

(a) pH water and KNO_3 extracts

(b) Total B. E. C.

(c) Total exchangeable metal cations

(d) Exchangeable calcium.

From (b) and (c) the degree of base saturation can be calculated easily. Statistical analysis of the data shows that treatment variance is significant in the following cases :

pH of KNO_3 extract	significant at	$P = 0.001$
Exchangeable calcium	,,	,, $P = 0.01$
Total exchangeable metal cations	,,	,, $P = 0.05$
Degree of base saturation (calculated values)	,,	,, $P = 00.5$

Mean values for the treatments and the difference required at $P = 0{\cdot}05$ are shown in the following table.

	Inorganic fertiliser	Check	Cattle manure	S.D. reqd. at P = .05	Remarks.
pH water extract	5·17	5·49	5·44	0·33	Difference between I.F. and check is 0·32 and just fails to be significant.
pH KNO_3 extract	4·23	4·48	4·31	0·10	Both I.F. and C.M. values significantly lower than check.
Total B. E. C. m.e./100 gms.	6·15	6·28	6·43	1·45	
Exchangeable calcium cations m.e. /100 gms.	1·17	1·73	2·33	0·72	The difference between C.M. and I.F. is significant.
Exchangeable metal cations m.e. /100 gms.	0·63	1·23	1·34	0·39	I.F. significantly lower than both C.M. and Check.
Degree of Base Saturation (%)	19	28	38	14	Difference between C.M. and I.F. is significant.

The differences between the two treatments are as one might have expected. In this particular case the inorganic fertiliser used consisted not only of Sulphate of Ammonia but also some quantity of Superphosphate and Muriate of Potash. The latter would not be expected to have any appreciable effect on the exchange complex and Sulphate of Ammonia must be held responsible for the decrease in total exchangeable metal cations and exchangeable calcium.

Soil and Climatological maps of N.E. India. The following maps have been prepared for publication.

(i) Mean annual rainfall of N.E. India tea areas

(ii) Main soil types of N.E. India tea areas.

Climatology.—The total rainfall during the year was not much below normal but the distribution has been extremely irregular. Rainfall and the number of wet days during March 1953 were the highest ever recorded during the month at Tocklai. Rainfall was well below normal during the monsoon months of June, July and August and during the last quarter again it was scanty. The number of wet days recorded follow the rainfall figures. Sunshine hours recorded exceeded the normal values in all months excepting March and September. On the whole, temperatures have been above normal and the humidity values well below normal.

Table A

1953	Monthly average temperatures °F		Sunshine in hours (daily average)	Rainfall (inches)	Wet days	Average for 30 yrs,	
	Maximum	Minimum				Rainfall (inches)	Wet days
January	71.33	48.07	6.62	0.70	5	0.89	5
February	77.25	53.36	6.84	0.09	1	1.31	8
March	79.53	63.68	4.78	11.87	20	3.54	11
April	83.92	66.64	6.40	5.63	12	7.73	17
May	86.59	71.01	5.39	12.95	22	10.59	20
June	90.38	75.95	6.39	8.75	23	12.90	23
July	89.96	76.05	5.24	12.90	26	15.11	25
August	91.64	76.72	6.74	8.63	19	13.08	23
September	86.20	73.95	4 36	13.97	19	10.80	20
October	84.35	68.23	5.82	3.42	11	4.47	11
November	80.35	57.74	7.57	0.04	1	1.10	4
December	70.04	52.99	6.73	0.46	5	0.41	3
Total			72.88	79.41	164	81.93	170
Average	83.13	65.37	6.07				

Table B

(i) Relative Humidity

(monthly averages)

1953	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
8 a. m.	94	91	91	85	88	87	90	89	92	93	93	94
12 noon	67	58	75	66	75	75	76	77	79	74	63	66
2. p. m.	56	50	68	60	70	72	75	72	77	69	58	59

(ii) Vapour Tension in inches of mercury

(monthly averages)

1953	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
8 a. m.	.365	.448	.603	.669	.784	.897	.924	.949	.887	.750	.548	.447
12 noon	.432	.470	.623	.688	.809	.906	.929	.952	.898	.768	.585	.511
2 p. m.	.402	.456	.602	.686	.803	.899	.948	.950	.912	.765	.570	.494

TABLE C.

Soil Temperatures° F, Soil Moisture and Evaporation from a standard evaporimeter

1953	Soil temperature at 1 ft.				Soil temperature at 3 ft.				Soil moisture % (top 9)	Evaporation inches daily mean
	Fallow		Grass		Fallow		Grass			
	8 a.m.	2 p.m.	8 a.m.	2 p.m.	8 a.m.	2 p.m.	8 a.m.	2 p.m.		
January	64·62	64·28	64·62	64·57	69·76	62·64	68·28	68·06	12·93	0·055
February	67·37	67·74	66·80	67·44	69·23	69·38	68·59	68·73	11·54	0·091
March	73·07	73·12	73·32	73·44	73·11	73·20	73·67	73·77	16·93	0·132
April	77·66	78·16	78·42	78·58	76·26	76·20	77.77	77·88	16·64	0·158
May	81·38	81·82	81·82	82·06	79·53	79·56	81·34	81·01	17·76	0·133
June	84·81	84·92	85·47	85·37	*	*	84·27	84·03	16·80	0·160
July	85·88	86·01	86·81	86·73	*	*	86·00	86·06	18·29	0·151
August	87·54	87·78	88·34	88·38	*	*	87·59	87·70	18·67	0·155
September	84·11	84·40	35·71	84·78	*	*	85·17	85·10	18·83	0·106
October	80·33	80·48	81·41	81.35	*	*	82·34	82.19	17·18	0·089
November	73·68	74·16	74·77	74·94	77·63	77·60	77·32	77·24	15·05	0·067
December	68·29	68·90	69·21	64·85	73·02	73·15	72·14	72·15	13·78	0·052

*Thermometer out of order

ENTOMOLOGICAL BRANCH

Staff.—G. M. Das, M.Sc., Ph.D., D.I.C.—Senior Entomologist.

Mr. N. S. Sen Gupta, B.Sc., joined this Branch on 2nd January as Assistant Entomologist.

General.—An outbreak of Red slug caterpillar was reported from some gardens in the Dooars. Incidence of Looper caterpillar was severe in a few gardens in Golaghat.

Red Spider.—Although sexual multiplication is a common phenomenon in Red spider, it can also breed asexually for two generations, the progeny being both males and females in the proportion of 7 : 1 in the first generation but the second unfertilised generation produces all males.

Control.—Ovotran (p-chlorophenyl p-chlorobenzene sulfonate) has little effect on the active stages of Red spider which migrate shortly after the treatment is applied. It has, however, been found to be highly effective against eggs and caused 80-90% mortality (vide Annual Report 1952, p. 51). In one experiment where the treatment was applied some time after the eggs were laid, the mortality was decidedly low. It was therefore thought that the time factor i.e., the interval between the date of egg-laying and the date of spraying, might have some influence on the ovicidal action of Ovotran, and this was confirmed by a trial in which the treatment was applied at intervals, the date of egg-laying being constant.

TABLE I

Treatments	Dilution	Date of laying eggs	Date of treatment	Total eggs hatched	Total eggs not hatched	% Unhatched eggs
Ovotran (thorough spray)	1 lb. to 50 gals. water	27/28.153	28-1-53	112	410	78.5
—do—	1 ,, 100 ,,	,,	,,	149	296	66.5
—do—	1 ,, 50 ,,	,,	31-1-53	22	165	74.7
—do—	1 ,, 100 ,,	,,	,,	80	139	63.4
—do—	1 ,, 50 ,,	,,	3-2-53	82	168	67.2
—do—	1 ,, 100 ,,	,,	,,	114	94	45.2
—do—	1 ,, 50 ,,	,,	6-2-53	269	163	37.7
—do—	1 ,, 100 ,,	,,	,,	417	97	18.8
Control	Untreated	,,	,,	306	15	4.6

From the above Table it is evident that freshly laid eggs are more affected by Ovotran than those laid earlier, and as the interval between the date of egg-laying and the date of treatment increases, the ovicidal action is reduced. In the field where the eggs in all stages of development are found, the mortality of eggs may not be as high as 80-90% but it can be expected to give about 60% mortality there.

Effect on quiescent forms.—Further study on the effect of Ovotran on quiescent forms of Red spider was made under laboratory conditions. The results are given in the following Table.

TABLE II

Treatments	Quiescent forms			Per cent killed
	Total	Moulted	Not moulted	
A. Ovotran 1 lb. to 15 gals. of water—Heavy spray	121	94	27	22.3
B. ,, ,, Normal ,,	142	123	19	13.4
C. Ovotran 1 lb. to 100 Gals. water—Heavy spray	84	73	11	13.1
D. ,, ,, Normal ,,	139	121	18	12.9
E. Control	136	135	1	0.7

The kill of quiescents was sligthly more than that obtained in the previous year but it cannot be called satisfactory.

Residual effect on the newly hatched larvae.—It was not possible to estimate definitely the persistent action of Ovotran on newly hatched larvæ of Red spider as most of them dropped from the treated leaves. The leaves with counted number of freshly hatched larvæ were pinned to the treated leaves. Most of the migrated larvæ however dropped. The following Table will show the percentage of larvæ killed on the treated leaves after 12-24 hours.

TABLE III

Treatments	No of larvæ introduced	No. of larvæ living	Percent living	No. of larvæ killed	Per cent killed	No. of larvæ dropped	Per cent dropped
A	201	22	10·9	20	10·0	159	79·1
B	177	35	19·8	11	6·2	131	74·0
C	201	45	22·4	8	4·0	148	73·6
D	202	75	37·1	7	3·5	120	59·4
E	196	127	64·8	2	1·0	67	34·2

It may be mentioned here that some of the larvæ which dropped from the treated leaves were found dead on the table, on the following morning.

Penetration of Ovotran.—Ovotran is said to penetrate through the leaf tissue and affect the eggs on the other surface of the leaves. In an experiment, the under surface of the leaves was brushed with Ovotran spray with the following results.

TABLE IV

(Shoots in tube)

Treatments	Total eggs	Hatched	Not hatched	Per cent un-hatched eggs
Ovotran 1 lb, to 50 gals. water.	203	198	5	2·5
-do- ,, ,, 100 ,, ,,	214	211	3	1·4
Control	194	193	1	0·5

TABLE V

(In pot culture)

Treatments	Total eggs	Hatched	Not hatched	Per cent unhatched eggs
A	106	101	5	4·7
B	76	73	3	3·9
C	98	98	0	0·0

A negligible percentage of eggs may be affected by such penetration, if there be any.

As Ovotran is effective against eggs, it may be combined with H. E. T. P. or Parathion to kill the active population of Red spider but the use of Organo-phosphorus compounds on tea is strongly discouraged for various reasons. As an alternative, sulphur preparations were combined with the spray of Ovotran to destroy active forms, and a small field trial was carried out with Ovotran plus Lime sulphur* and Ovotran plus Spersul along with some other acaricides at Tocklai and an estimation of kill of active forms was made from 10 leaves selected at random from different parts of the bushes, 24 hours after the treatment, with the following results.

*Lime sulphur appears to precipitate in the presence of Ovotran but the application was made soon after the spray had been made up.

TABLE VI

Treatments	Top leaf		Lower leaf	
	Active forms		Active forms	
	Living	Dead	Living	Dead
Modified Whiz 1 in 80 parts water. ...	5	169	37	31
Ovotran 1 lb. plus Lime sulphur 1·25 gals. in 50 gals. water ...	0	152	0	51
Lime sulphur 1 in 40 parts water ...	0	124	0	67
Ovotran 1 lb. plus Spersul 5 lbs. in 50 gals. water ...	6	183	14	98
G. 24353, 1 in 500 parts water	7	232	28	173
Diphenyl sulphone, 1 in 1000 parts water (0. 1%) ...	304	25	223	2
Control ...	351	0	245	1

There was heavy rain after 30 hours and the experiment was discarded.

Another field trial was conducted at Borbhetta with Ovotran in combination with Lime sulphur and Colloidal sulphur as high and low volume sprays. There is practically no difference between the action of Lime sulphur and Collodial sulphur on the active forms, and when they are applied as low volume and high volume sprays.

Treatment A—Ovotran 1 lb. plus Lime sulphur 12.5 lbs. plus water 50 gals. Low volume spray.

" B— -do- -do- High volume spray.

Treatment C—Ovotran 1 lb. plus Collodial sulphur 1.25 lbs. plus Sandovit @ 2½ ozs. per 10 gals. Low volume Spray.

,, D— -do- -do- -do- High volume spray.

,, E—Control.

TABLE VII.

Date of Spraying—25-4-53.

Treatments	Active forms on the 3rd day of spraying		Quiescents on the 4th day of spraying		Eggs on the 10th day of spraying	
	Living	Killed	Living	Killed	Apparently healthy	Apparently affected
A	0	156	0	25	0	581
B	0	279	0	34	0	1233
C	0	181	0	13	0	877
D	0	98	0	16	0	629
E	475	0	92	0	1006	0

No definite estimation of percentage of egg-mortality could be made, as there was hatching in the meantime before the final count was taken. The number of affected eggs with Lime sulphur plus Ovotran as a high volume spray was, however, higher than that obtained with a low volume spray, and also with Collodial sulphur plus Ovotran as low and high volume sprays.

In a further trial, addition of wetting agent to Lime sulphur was found to increase the mortality of eggs and quiescents more than Lime sulphur alone, but Ovotran plus Lime sulphur gave the highest mortality of eggs and quiescents.

Treatment A—Lime sulphur 1 in 40 parts water.

,, B— -do- -do- plus Sandovit (2½ ozs. per 10 gals.).

,, C—Lime sulphur 12.5 lbs. plus Ovotran 1 lb. plus water 50 gals. plus Sandovit (2½ ozs. per 10 gals.)

,, D—Control.

TABLE VIII

Date of spraying—23-4-53

Treatments	Active forms on the 2nd day of spraying		Quiescents on the 5th day of spraying		Eggs on the 9th day of spraying	
	Living	Killed	Living	Killed	Apparently healthy	Apparently affected
A	0	392	0	16	0	287
B	0	292	0	31	0	422
C	1	501	0	41	0	748
D	427	7	26	0	2025	0

Further field trials are proposed to test the efficacy of Ovotran in combination with Collodial and Wettable sulphur.

Aramite (9-(p-tert-butylphenoxy) isopropyl 2-chloroethyl sulfite) :

This acaricide was obtained from U. S. A. and tested against Red spider in the laboratory.

Effect of Aramite on the active forms of Red spider.

Treatments A —Aramite—15 W (1 lb. to 50 gals. water).

,, B — ,, 15 W (1 lb. to 100 gals. of water).

,, C—Control

TABLE IX

Date of spraying—1-6-53.

Dates of observation—1-6-53, 2-6-53 and 3-6-53.

Treat-ments	Total No. of active form	No. of active forms killed	Per cent of active forms killed	No. of active forms living	Per cent of active forms living	No. of active forms mig-rated	Per cent of active forms mig-rated	No. of active forms formed quies-cents	Per cent formed quies-cent
A	387	251	64·9	0	0·0	127	32·8	9	2·3
B	443	206	46·5	4	0·9	216	48·8	17	3·8
C	304	12	3·9	247	81·3	18	5·9	27	8·9

A high percentage of active forms were killed by Aramite at 1 lb. in 50 gallons of water and the rest migrated from the treated leaves. Most probably they died in a day or two as is evident from the Tables 10,12 and 13,

Of the active forms which migrated, a few (8 from Treatment A and 11 from Treatment B) were found dead on the table on the following day and the rest could not be traced.

In another experiment the adult Red spiders migrating from the treated leaves were kept on fresh leaves in tubes. In the control the adult Red spiders were collected from untreated leaves.

TABLE X

Treat-ments	No. kept in tubes on 1.6.53.	On 3. 6. 53.		On 3. 6. 53.		Total No. of eggs laid in 2 days
		No. died	No. of eggs laid	No. died	No. of eggs laid	
A	25	24	0	1	0	0
B	29	26	1	3	0	1
C	14	0	56	3	65	121

Almost all the Red spiders from the treated leaves died within 24 hours and none was found alive after 48 hours, whereas in the control there were only 2 deaths within 48 hours, after which the observation was discontinued. The total number of eggs laid by the Red spiders collected from untreated leaves was 121 in two days but very few eggs were laid by the Red spiders from the treated leaves.

The trial was repeated (with the same treatments) against active forms of Red spider with the following results.

TABLE XI

Treatments	Total No of active forms	No. of active forms Killed	Per cent of active forms killed	No. of active forms living	Per cent of active forms living	No. of active forms migrated	Per cent of active forms migrated	No. formed quiescents	Per cent formed quiescents
A	349	275	73.6	0	0.0	92	26.4	0	0.0
B	412	200	48.5	0	0.0	83	20.1	129	31.3
C	449	10	2.2	353	78.6	6	1.3	80	17.8

The results corroborated the findings of the previous trial that a high percentage of active forms are killed by Aramite. Those young Red spiders forming quiescents after treatment did not moult and were found dead whereas those in the control moulted in due course.

A number of migrating adults were again kept on fresh leaves in tubes with the following results.

TABLE XII

Treatments	No. kept in tube on 11.6.53	On 12. 6. 53.		On 13. 6. 53.		Total No. of eggs laid in 2 days.
		No. died	No. of eggs laid	No. died	No. of eggs laid	
A	31	27	10	3	13	23
B	9	9	0	...	...	0
C	20	0	52	1	26	78

Almost all the Red spiders from the treated leaves died within 24 hours and there was practically no living Red spider after 48 hours, but in the control where the Red spiders were collected from fresh leaves, 19 out of 20 were found alive after 48 hours.

The eggs laid on fresh leaves by Red spiders collected from the treated leaves hatched in due course.

In another trial 10 adults migrating from each Aramite treatment and 10 collected from untreated leaves were kept on fresh leaves in tubes.

TABLE XIII

Treatments	No. kept in tube on 19-6-53	On 19-6 53.		On 21-6-53.		On 22-6-53.		Total No. of eggs laid in 4 days
		No died	No. of eggs laid.	No. died	No. of eggs laid	No. died	No. of eggs laid	
A	10	9	0	1	0	0	0	0
B	10	8	0	1	0	1	2	2
C	10	0	39	0	15	3	9	63

The adult Red spiders from the treated leaves did not survive long and died without depositing eggs.

Effect of Aramite on the eggs of Red spider.

TABLE XIV

Treatments	Total No, of eggs	No. of eggs not hatched	Percent unhatched eggs
A	209	189	90.4
B	467	177	37.4
C	250	20	8.0

TABLE XV

Treatments	Total No. of eggs	No. of eggs not hatched	Percent unhatched eggs
A	285	237	83.2
B	238	149	62.6
C	311	15	4.8

A very high percentage of egg-mortality was effected by Aramite at 1 lb. to 50 gallons of water, but results varied with Aramite at a lower concentration of 1 lb. to 100 gallons of water and the percentage of egg-mortality was not satisfactory in one trial. This point requires further confirmation.

Effect of Aramite on quiescent stages of Red spider

TABLE XVI

Treatments	Total No. of quiescents	No. of quiescents not moulted	Per cent killed
A	45	30	66·7
B	61	39	63·9
C	36	3	8·3

More than 60% of quiescents were killed by Aramite in both the treatments. It appears that those quiescents formed after the treatment are more affected than those formed before the treatment.

The persistent toxicity of Aramite has not yet been investigated.—***Conclusion***—From the foregoing data the following conclusions may be drawn on the effect of Aramite on tea Red spider.

a. A high percentage of active forms of Red spider are killed by Aramite W. P. at 1 lb. to 50 gallons of water.

b. The migrating Red spiders from the treated leaves do not survive long but die without practically depositing eggs.

c Aramite also affects a high percentage of quiescent forms and those quiescents formed soon after the treatment is applied are more affected than those formed before the treatment.

d. A very high percentage of egg-mortality is obtained with Aramite at 1 lb. to 50 gallons of water.

G.24353 (ethyl ester of 4. 4-dichloro-benzilic acid)

Effect of G. 24353 on the active forms of Red spider under laboratory conditions

Treatment A—G.24353 1 in 500 parts of water.

,, B— ,, 1 in 1000 ,, ,,

,, C—Control.

TABLE XVII

Treatments	Active forms			Per cent killed
	Total	Not Killed	Killed	
A	262	0	262	100·0
B	528	0	528	100·0
C	197	190	7	3·6

This acaricide gives 100% mortality of the active forms when full coverage of all the infested leaves can be obtained.

Effect on quiescents under laboratory conditions

TABLE XVIII

(First Trial)

Treatments	Quiescents			Percent killed
	Total	Moulted	Not moulted	
A	84	4	79	94·0
B	82	41	41	50·0
C	46	40	6	13·0

TABLE XIX

(Second Trial)

Treatments	Quiescents			Percent killed
	Total	Moulted	Not moulted	
A	34	4	30	88·2
B	123	55	68	55·3
C	231	229	2	0·9

A very high percentage of quiescents were killed by G. 24353 at 1 in 500 parts of water but at a lower concentration of 1 in 1000 parts of water, about 50% mortality was obtained.

Effect on eggs under laboratory conditions

TABLE XX

(First Trial)

Treatments	Eggs			Per cent unhatched eggs
	Total	Hatched	Not hatched	
A	143	32	111	77·6
B	326	246	80	24·5
C	219	215	4	1·8

TABLE XXI

(Second Trial)

Treatments	Eggs			Per cent unhatched eggs
	Total	Hatched	Not hatched	
A	422	134	288	68·2
B	354	188	166	46·9
C	472	462	10	2·1

TABLE XXII

(Third trial)

Treatments	Eggs			Per cent unhatched eggs
	Total	Hatched	Not hatched	
A	244	33	211	86·5
B	285	134	151	53·0
C	304	295	9	3·0

G. 24353 at 1 in 500 parts of water gave 70-80% egg mortality, while at 1 in 1000 parts of water, the results were not very satisfactory.

Although G. 24353 gave promising results against all forms of Red spider under laboratory conditions, it was not found to be so satisfactory under field conditions in a small trial consisting of only a few infested bushes. The efficiency of this acaricide can only be judged from large scale field trials proposed to be carried out shortly.

Diphenyl sulphone.—This acaricide has practically no effect on active forms of Red spider and the percentage of egg-mortality was so low that there is little prospect of using it either alone or in combination with another acaricide for control of Red spider of tea.

Conclusion.—From the results so far obtained in the laboratory it appears that Aramite might be an answer to Red spider. The results obtained with Aramite in a small field trial consisting of a few infested bushes during cold weather were almost equally satisfactory and the population of unaffected Red spider on the treated bushes on the 16th day of treatment was negligible. Whether one application of Aramite would control the Red spider during the flushing season or a second round of spray (after the incubation period is over) would be necessary or it would be preferable to combine a sulphur preparation with Aramite for one application can only be ascertained after the completion of the field trials which are to be conducted shortly.

Termite control—The persistent toxicity of Aldrin and Dieldrin in the plots treated in 1952 at Tarajulie Tea Estate was estimated for another year with the following results.

TABLE XXIII

Treatments	Rate per acre	Number of earth runs in						
		March	May	July	Sep.	Nov.	Jan.	TOTAL
Aldrin 50% W.P. ...	8 lbs.	1	4	1	5	24	35	70
do do ...	16 ,,	0	2	0	3	6	6	17
do do E.C. ...	8 ,,	1	5	2	5	8	11	32
Dieldrin 50% W.P....	8 ,,	2	3	0	3	5	3	16
do do ...	16 ,,	1	4	0	2	3	1	11
do do E.C. ...	8 ,,	2	7	2	4	6	2	23
Control ...	Untreated	38	28	15	53	108	160	402

The toxicity of Aldrin and Dieldrin persists in the soil at least for two years from the date of application. It is yet to be seen how long this residual action may last.

A further replicated randomised trial with Aldrin and Dieldrin along with B.H.C. for comparison was conducted at Tarajulie Tea Estate with the following results.

TABLE XXIV

Treatments	Rate per acre	Number of earth runs per bush in			
		July	September	November	January
		Mean of 5 replications			
Aldrin 50% W. P.	16 lbs.	0·024	0·160	0·368	0·424
Dieldrin 50% W.P.	16 lbs.	0·015	0·072	0·208	0·104
Gammexane D. 025 as dust	190 lbs.	0·048	0·304	1·168	1·448
Control	Untreated	0·152	0·552	2·232	1·584
Mean C. D.	—	Insignificant	0·266	0·974	0·666

Conclusion.—In all cases, Dieldrin gives the best result followed by Aldrin. Though the July observation gives insignificant result, the obtained value of F is very near to the value of F in the table at 5% level of significance. There is, however, a trend of this result being significant ; in fact it may be so at 7% level of significance.

The rate of 16 lbs. of Aldrin or Dieldrin per acre applied in these experiments is said to be too high by the manufacturer and it is suggested that 2 lbs. per acre should give adequate check to the activities of termites. From the incidence of termites in the same year of treatment, it appears that both Aldrin and Dieldrin give considerable reduction in termite activities, but the rate of 16 lbs. of Aldrin is better than the rate of 8 lbs. per acre, whereas there is little difference in the activities of termites between the plots treated with 8 lbs. and 16 lbs. of Dieldrin (vide Annual Report 1952, p. 49). The toxicity persisting in the following year (vide Table 23) also corroborated the above findings.

Further trials have already been arranged to find out the minimum rate of Aldrin and Dieldrin required to give sufficient check on the activities of the termites, so that it may not be uneconomical to treat with any of the two materials the vast termite infested areas of tea in the Darrang District.

Rhesela moestalis, Walk, defoliating nursery and young shade plants.—Preliminary studies on the life-history of this pest have been made. The eggs are laid singly on the under surface of the leaflets, petioles and tender stems of young shoots. The caterpillar at first feeds on the epidermal layer of the leaves and then webs up a few leaves and feeds inside.

The caterpillar is of green colour and when full-grown measures about an inch in length. A day or two before pupation it assumes a reddish brown or brick-red colour. It comes down suspended on a silken thread to pupate in the soil or under rubbish nearby.

Duration of various stages is May-June.

Egg stage	...	7 days
Larval stage	...	12-13 days.
Pupal stage	...	7-8 days.

The whole leaf-cycle is completed in 26—28 days.

There are several broods in a year which overlap, and it is difficult to separate one generation from another. The caterpillars can be found almost at any time between the end of February and the middle of November. However, there appear to be at least six broods in a year and the approximate time of occurrence of caterpillars of different broods on young *Albizzia odoratissima* shade at Borbhetta is given below.

1st brood—End of February to 1st week of April—Very slight attack.

2nd ,, —2nd week of April to 3rd week of May—Slight attack.

3rd ,, —End of May to 1st week of July—Severe attack.

4th ,, —2nd week of July to middle of August—Severe attack.

5th ,, —3rd week of August to end of September—Moderate attack.

6th ,, —1st week of October to middle of November—Very slight attack.

Control.—DDT and BHC are quite effective in dealing with the pest in the existing infestation (vide Annual Report 1952).

The residual action of these insecticides persists for about a month but there may be little residue on the new growth, particularly in the growing season, which is subject to re-infestation. The treatment has therefore to be repeated as a preventive or control measure against fresh attacks.

In a trial with Verindal Ultra (Lindane), Gammexane W. P. and dust, and DDT at Dhekiajuli Tea Estate, Verindal Ultra (Lindane) at 1 lb. in 100 gallons of water was found to give the best results and all the caterpillars dropped on the ground from the nursery plants within half an hour of application and died instantaneously. DDT and Gammexane were, however, slower in action.

Cockchafer grubs.—Trials with Intox '8' (liquid and dust) were carried out against Cockchafer grubs in the laboratory but the results were not satisfactory.

Tea seed bug.—The life-history of this pest was studied in the laboratory.

Duration of various stages—

Incubation period	... 5—8 days.
1st Nymph stage	... 4—6 ,,
2nd ,, ,,	... 4—6 ,,
3rd ,, ,,	... 5—7 ,,
4th ,, ,,	... 6—9 ,,
5th ,, ,,	... 11—14 ,,

Most of the young insects of the September brood did not have the usual 5th moult but passed the winter in the last young stage.

Control.—Two materials viz., Verindal Ultra (Lindane) and Multanin Ultra (Lindane plus DDT) were tested against adults and nymphs of Tea seed bug without any satisfactory results.

TABLE XXV

Treatments	Total bugs	Kill within 7 days
Verindal Ultra (1 lb. in 100 gals. water)	10	2
Multanin Ultra (1 ,, ,, 66·7 ,, ,,)	10	0
Control	10	0

Looper caterpillar.—A series of experiments with Verindal Ultra (Lindane), Multanin Ultra (Lindane plus DDT), Murphy's DeDeTane Paste and Geigy's Guesarol 550 was carried out against full-grown Looper caterpillars under laboratory conditions. Verindal Ultra was found to be highly effective and gave 100% kill within 36 hours and Multanin Ultra within 72

hours of treatment. DDT was found to be inferior to both Lindane and Lindane plus DDT. DeDeTane Paste was, however, found to be similar to Guesarol 550 in its action.

Lindane is a highly toxic insecticide and could have been recommended against Looper caterpillars had it not tainted the made tea. Although Lindane Plus DDT had not tainted the tea, there was a suspicious under current in the cup. It therefore appears that Lindane or Lindane plus DDT can only be used in extreme cases, where a severe outbreak of Looper has already badly defoliated the bushes, and any further damage to new growth is likely to affect adversely the health of the bushes or might even result in their death. In such cases, no plucking should be done for manufacture for some time.

Tainting effect on made tea—In an experiment, the plots were treated with Lindane, Lindane plus DDT and Chlordane (Intox '8' liquid and dust), and plucked after a week. A report from the Tea Taster is as follows.

TABLE XXVI

Treatments	Sample No.	Remarks	Mark for liquors
Intox '8' liquid 1 in 500 parts of water	2	No taint	6
	6	No taint	6
Intox '8' dust 5% @ 15 lbs. per acre	5	Not tainted but a suspicious under current in the cup	4
	8	No taint	4
Lindane plus DDT, 1 lb. to 66·7 gals. of water	3	Not tainted but a suspicious under current in the cup	4
	10	do do do	6
Lindane 1 lb. to 100 gals of water	4	Distinctly tainted	0
	9	do do	0
Check	1	No taint	10
	7	do	10

From the above table it is evident that tea made from all the treated plots was inferior to the check (untreated) but that made from plots treated with Lindane was definitely tainted.

Tea Chest Borers.—For the control of Tea Chest Borers, an experiment was carried out at Dahingeapar Tea Estate where 40 infested panels were subjected in batches of 5 to temperatures of 150, 175, 200 and 250°F for periods of 5 and 10 minutes. The treated panels were brought to Tocklai laboratory and were examined on 5 occasions. The persistence of attack was recorded as indicated by the freshly ejected dusts from the tunnels.

TABLE XXVII

Presence of borers in the treated panels

Subject to temperature of	For	Average number of live borers as indicated by freshly ejected dusts
150°F	5 minutes	11·0
,,	10 ,,	0·2
175°F	5 ,,	4·2
,,	10 ,,	0·2
200°F	5 ,,	1·4
,,	10 ,,	0·0
250°F	5 ,,	1·0
,,	10 ,,	0·0

From the above results, it is evident that the treatment for 10 minutes of infested panels under temperatures of 200°F and 250°F ensures complete destruction of borers including eggs.

The plywood did not split up nor did it show any sign of distortion in any of the panels subjected to temperatures between 150 and 250°F for 5 and 10 minutes. A further number of panels treated at 200°F for 15 minutes also did not show any sign of distortion.

The panels should not be put into the drier in stacks as this will possibly prevent the centre of the panels from receiving the full heat treatment.

The treated panels should on no account be stored in the same place where the infestation has occurred but be removed to another building. This treatment does not guarantee against a fresh infestation from outside.

In another trial Methyl Bromide was tried in an air-proof rubber chamber but this treatment proved unsatisfactory in controlling the borer in the panels.

115 badly infested panels were placed inside an air-proof chamber 3′ × 3′ × 3′ and treated with Methyl Bromide (one ampoule containing 20 cc crushed inside). The cover was removed 24 hours after treatment and an estimation of borer infestation was made from the freshly ejected dust on the 11th day of treatment.

TABLE XXVIII

	Total panels	Total infestation	Infestation per panel
Treated	115	91	0.79
Check	25	86	3.44

There was a reduction in the infestation in the treated panels and this might have been caused by the destruction of adults and larvæ, but Methyl Bromide appears to have little effect, if there be any, on the eggs which hatched in due course and started reinfestation. Whether a second treatment will ensure complete control of borers is a point which can only be ascertained by further investigations.

Whether dusting the edges and top of the stacks with DDT after heat treatment would prevent further infestation from outside and whether DDT would taint the stored tea, are being investigated.

Systematic study. Systematic study of tea pests was undertaken, because certain pests in our collection had been wrongly determined. The generic and specific name of many species has been changed since the publication of "Pests and Blights of Tea" by Watt and Mann in 1903 and some new pests have also occurred in the meantime, which required immediate attention.

Advisory—87 specimens of insect pests were examined and reported on.

239 letters and memoranda were issued in connection with pests of tea and ancillary crops.

26 samples of insecticides were received for test.

Publications—The following Tea Encyclopaedia Serials were pulished during the year.

1. Control of Pests and Diseases of Boga medeloa—Serial No. 44/1, filed under E.1 (in conjunction with Mycologist).

2. Control of Mound-building Termites—Serial No. 52/1, filed under J.3.

Touring—The Entomologist visited 2 gardens in Upper Assam and 12 local gardens.

MYCOLOGICAL BRANCH

Staff—K. C. Sarmah, Mycologist

The Mycologist was on Annual Leave for one month from the 2nd of November.

Mr. G. C. Sarma Barua, B.Sc., was appointed in January as Junior Assistant in the Intermediate Grade.

Bacteriology. Weekly bacteriological tests of the Tocklai water supply were carried out throughout the year with the following results.

Months	Untreated tank water		Treated water	
	Total bacteria per c.c.	Lactose fermenters per c.c.	Total bacteria per c.c.	Lactose fermenters per c.c.
January	11	2	1	0
February	12	5	2	0
March	21	10	1	0
April	24	16	1	0
May	16	11	1	0
June	17	13	1	0
July	13	9	1	0
August	11	3	2	1
September	11	8	2	1
October	22	19	1	1
November	9	5	1	0
December	21	8	1	0

The treated water was free from contamination.

11 samples of water received from outside estates were tested for bacterial contamination.

Mycology. –***Sun-scorch*** -Severe damage from Sun-scorch occurred practically throughout the whole of the plains districts once in June and again in August. Most of the tea growing under poorly shaded conditions developed chocolate red patches on the leaves covering the entire area exposed to the sun. Unshaded and adequately shaded teas did not suffer so much as the irregularly shaded ones.

Effect of water-logging on Albizzia odoratissima.—During the year severe attacks of Violet root rot (*Sphaerostilbae repens*) were noticed in the roots of *Albizzia odoratissmia* shade growing in heavy types of soil or where the subsoil at a depth of about 3 or 4 feet was heavy clay. The trees made splendid growth in certain cases for 3 or 4 years after which the tops looked yellowish and sickly, the leaves started to drop off and the branches died back. Such trees, examined from very widely separated areas in the Assam Valley showed obvious signs of waterlogging followed by severe infection of Violet root rot with all the characteristics (viz., colour, smell and mycelial strands); they also lodged easily during storms.

Albizzia odoratissima—has been observed also in the past to be very susceptible to waterlogging and Violet root rot. It is known to grow well only in well drained soils. No further attempt should be made to grow it in areas where it has failed in the past due to the above conditions of soil. It would be better to use *Albizzia procera* (Koroi) as a substitute in such places.

Blister blight.—The total number of gardens which reported the occurrence of the disease is shown month by month in the following table.

Months	Assam	Cachar	Dooars	W. Bengal	E. Pakistan
January ...	1	...	3	3	...
February ...	4	1	1	1	1
March ...	3	...	1	...	...
April ...	30	...	2	...	...
May ...	6	...	...	...	...
June to Oct. ...	No	Blister	blight	reported	
November ...	1	...	...	...	...
December ...	1	...	1	...	...

The blight appeared in an epidemic form in the month of April in many of the Assam gardens as a result of unusually cold and wet climatic conditions which prevailed practically throughout the whole of March and the first half of April. It gradually lifted with the rise in temperatures in early May and disappeared completely by the end of the month.

Black rot--***Winter spraying experiment at Katanibari T. E.***—20 plots of 100 bushes each were sprayed on 2 occasions at an interval of 2 weeks during last week of January to middle of February 1953, before bud break took place. The following treatments were applied.

Treatments—

A. Oil soluble mercury fungicide

B. Perenox 0·25% plus Ovicide 25%

C. Perenox 0·25% plus Tar Oil 2·5%

D. Perenox 0·25% plus Ovicide 1% during mid-April and end of May (This was intended for comparison with treatment B).

E. Control.

There were 4 replicates in each treatment. Low volume nozzles were used for spraying.

Monthly observations from July to October on the incidence of the disease gave the following results.

Treatments	Total incidence of Black rot during				Total of 4 observations
	July	August	September	October	
A	134	155	181	280	750
B	159	160	215	288	822
C	127	153	197	254	731
D	94	66	108	150	418
E	111	140	172	231	654

None of the winter treatments was found to be effective in controlling the disease satisfactorily. Treatment D (applied during the prophylactic period), however, gave an appreciable reduction in the incidence of the disease as compared with treatment B which was almost identical.

Prophylactic treatment at Katanibari T. E.—This treatment was applied once during the third week of April and again in the 1st week of May, using 10 fungicides at 0·25% concentration.

There were 33 plots of 25 bushes each under 11 treatments including the check (i. e., 3 plots to each treatment). Low volume nozzles were used for spraying.

Monthly observations, on the incidence of the disease, from July to October gave the following results.

Treatments	Total incidence of Black rot during				Total of observations
	July	August	September	October	
1. Perenox ...	10	23	28	39	100
2. Supercuprenox	16	45	51	59	171
3. Cuprox ...	2	11	19	18	50
4. Dithane ...	2	10	9	15	36
5. Cuprokylt ...	8	15	12	16	51
6. Cupromox ...	2	13	20	26	61
7. Cupravit ...	10	10	19	24	63
8. S. R-406 ...	16	17	13	26	72
9. Fungex ...	21	20	23	29	93
10. Yellow cuprocide	6	5	18	29	58
11. Control ...	21	42	40	48	151

Most of the above treatments gave appreciable reduction of the disease during the plucking season. Treatment No. 1, Perenox, was used from an old stock. It gave a little less reduction than usual probably due to partial deterioration in storage.

Red rust—***Winter treatments at Sycotta T. E.***—The following fungicides were applied immediately after pruning on young

tea at Sycotta Tea Estate. The treatments were applied as sprays, to six randomised rows of 25 bushes each, on two occasions at an interval of 2 weeks.

1. Oil soluble Mercury fungicide supplied by M/s. Murphy's Chemical, applied @ 1 pint per 100 gallons of water.
2. An I. C. I's product Capsine 5%.
3. No. 1 treatment @ 2 pints per 100 gallons (double the recommended strength).
4. Tar Oil 5% and Perenox 0.25%.
5. Control.

Assessment of Red rust was made during the fruiting period, once in June and again in July. Observations were based on the fructifications on the stem and also variegation on the leaves. The relative amount of Red rust was estimated as —

No Red rust ... 0
Slight ,, ... 1
Medium ,, ... 2
Heavy ,, ... 3

The results are tabulated below.

Treatments	9th June		9th July		Average	
	Degree of infection	Variegation	Degree of infection	Variegation	Degree of infection	Variegation
1. Oil soluble Mercury fungicide 1 pt. to 100 gals. of water.	64	49	60	52	62	50
2. Capsine 5%	73	66	76	72	74	69
3. No. 1 at double strength.	67	61	66	62	66	61
4. Perenox 0.25% plus 5% Tar Oil	37	24	46	43	41	33
5. Control	78	63	76	65	77	64

Only Treatment No. 4 (Perenox 0.25% plus Tar Oil 5%) effected a reduction of about 47%.

Systemic fungicides.—The following chemicals supplied by two firms as systemic fungicides were tried out against Red rust on young tea at Sycotta Tea Estate.

1. Penta-chloro-phenoxy acetic acid
2. 2-4-5 Trichloro-phenoxy isobutyric acid

} Supplied by Pal Chemical Ltd.

3. 2-4-5 Trichloro-phenoxy acetic acid
4. 8-Hydroxyquinoline

} Supplied by I. C I.

Each of the above was applied at two concentrations viz., 1 in 1500 and 1 in 15,000 using 22·5 c.c. of the solution, i.e., 0·015 gm. and 0·0015 gm. respectively per plant. The solutions were sprayed on the foliage with an atomiser in one case and pipetted into the soil around the collar after partially exposing the surface roots in the other. Treatments were applied in the last week of April when the plants were in new leaf.

The treatments were as follows.

1. 1 in 1,500
2. 1 in 15,000

} Penta-chloro-phenoxy acetic acid

3. 1 in 1,500
4. 1 in 15,000

} 2-4-5 Trichloro-phenoxy-isobutyric acid

5. 1 in 1,500
6. 1 in 15,000

} 2-4-5 Trichlorophenoxy.acetic acid.

7. 1 in 1,500
8. 1 in 15,000

} 8-Hydroxyquinoline

9. Distilled water

10. Blank

There were three randomised plots of 10 bushes to each treatment on the foliage, as well as soil i.e., 60 bushes in each case (total 600 bushes).

The results are tabulated below.

TABLE I

Intensity of attack as judged by fructification

Treatments	Leaf treatment			Soil treatment		
	Dates of observation		Average	Dates of observation		Average
	9-6-53	9-7-53		9-6-53	9-7-53	
1	20	21	21	8	15	12
2	15	22	19	12	20	16
3	23	19	21	17	16	17
4	19	15	17	15	22	19
5	27	14	21	20	15	18
6	14	17	16	8	18	13
7	20	23	22	14	22	18
8	13	13	13	13	19	16
9	18	16	17	11	22	17
10	20	12	16	10	18	14

TABLE II.

Intensity of attack as judged by variegation of the leaves.

Treatments	Leaf treatment			Soil treatment		
	Dates of observation		Average	Dates of observation		Average
	9-6-53	9-7-53		9-6-53	9-7-53	
1.	8	19	14	6	10	8
2.	7	17	12	8	14	11
3.	8	19	14	9	8	9
4.	6	15	11	8	12	10
5.	5	8	7	10	8	9
6.	6	13	10	5	12	9
7.	8	17	13	6	16	11
8.	7	9	8	8	15	12
9.	8	15	12	3	12	8
10.	6	10	8	5	13	9

None of the treatments had any effect on the Red rust.

Nectria.—***Experiment at Panitola.***—Three-year old plants raised in pots on the laboratory verandah at Panitola were inoculated by the Scientific Officer, Jokai Tea Co., with cultures of Tippuk *Nectria* (parasitic) and conidial fructifications of *Nectria ochroleuca* (?). Young shoots up to 1 year were inoculated every month from October 1952.

All the shoots inoculated from October 1952 to February 1953 (40 in all) were examined but none of them showed any *Nectria* infection.

2-year old branches on healthy and vigorous young tea under plucking were inoculated with culture of Tippuk *Nectria* (parasitic) in October 1952. Examination of the inoculated stems failed to show any *Nectria* infection.

It would appear from the above that young stems up to about 2 years are not susceptible to attack by Tippuk *Nectria*.

Experiment at Tippuk.—Plots of 24 bushes (4 rows of 6 bushes) medium pruned at 24" were inoculated on the cuts with cultures of Tippuk *Nectria* (parasitic) and pink conidia *(Nectria ochroleuca*, each month commencing from September 1952.

Examination of all the cuts on the plots inoculated from September 1952 to February 1953 showed that—

(a) Cuts inoculated with cultures of pink conidia (probably *Nectria ochroleuca)* were not infected.

(b) Cuts inoculated with cultures of Tippuk *Nectria* (parasitic) only showed a certain amount of infection which appeared to vary according to the initial starch reserves in the roots of the bushes concerned.

There were more infected cuts on bushes which contained low reserves in their roots. Bushes having fair to good starch reserves, had either no infection or where some of them had been infected the disease did not extend very far.

From this it would appear that there is a direct relation between starch reserves (i.e., the health and vigour) of the bush

and the extent of infection and of damage by the disease. Strong and healthy bushes are resistant to infection to a great extent and are capable of throwing off the disease if they do become infected.

The experiment at Tippuk will be continued, for at least another season, with certain modifications.

Experiment at Tocklai—The last lot of monthly inoculations was made in the middle of October 1953. Observations are being continued.

Screening of fungicides—***Effect of seed dressings on Crotalaria anagyroides and Tephrosia candida seeds***

Tillex and Agrosan G.N., two seed dressings, were used to test their effect on fungal infection of the following seeds and also on germination.

1. **Tephrosia candida** } Strain 1 1952-53 from
2. **Crotalaria anagyroides** } Agri-Bot. Branch.

Both the varieties were separately treated with Tillex and Agrosan G.N. @ 0.08 gms. per oz. of the seeds (i.e., 300 gms. per 100 kilograms).

Half of both treated and untreated seeds were inoculated a week later with Fusarium spores obtained from cultures of *Tephrosia* roots killed by *Fusarium* wilt.

10 seeds were plated from each lot at fortnightly intervals on Potato-Dextrose-Agar up to 14 weeks after an initial interval of 4 weeks from the date of treatment and again at the end of 28 weeks therefrom. The seeds were kept on the laboratory table in cloth bags.

The results are as follows.

TABLE I

Number affected out of 20 seeds of Tephrosia candida

Treatments	Affected by	Dates of observation						
		Weeks						
		4	6	8	10	12	14	22
Tillex	Fungi	3	0	1	0	1	2	2
	Bacteria	0	0	3	0	2	3	17
Agrosan G. N.	Fungi	0	0	0	0	0	1	5
	Bacteria	0	0	0	0	0	0	18
Control	Fungi	20	20	19	19	13	12	5
	Bacteria	0	0	20	12	19	20	20

TABLE II.

Number affected out of 20 seeds of Crotalaria anagyroides

Treatments	Affected by	Dates of observation						
		Weeks						
		4	6	8	10	12	14	28
Tillex	Fungi	0	2	0	1	1	2	1
	Bacteria	0	0	13	9	12	16	20
Agrosan G. N,	Fungi	1	1	4	0	1	1	1
	Bacteria	0	0	4	6	5	4	20
Control	Fungi	18	18	7	10	5	5	2
	Bacteria	1	2	20	20	20	20	19

Taking *Tephrosia* and *Crotalaria* together, the number of seeds infected by the two organisms out of a total of 240 in 14 weeks and 280 in 28 weeks were as follows.

Treatments	Organism	Number of seeds infected			
		Out of 240 in 14 weeks	%	Out of 280 in 28 weeks	%
Tillex	Fungi	13	5·4	16	5·7
Agrosan G.N	,,	9	3·7	15	5·3
Control	,,	166	69·1	173	61·8
Tillex	Bacteria	58	24·1	95	33·9
Agrosan G.N	,,	19	8·0	57	20·3
Control	,,	154	64·1	163	68·9

Germination tests were made after 14 weeks and 28 weeks of application of seed dressings, both in the soil as well as in a damp chamber in the laboratory. The results are as follows.

Number of germinated seeds out of 400

Treatments	In damp chamber after 14 weeks	In soil		Average
		After 14 weeks	After 28 weeks	
1. Tillex ...	190	207	178	192
2. Agrosan G. N	218	239	139	199
3. Control ...	202	210	169	194

Both Tillex and Agrosan G. N. reduced the intensity of fungal infection to a marked degree. Agrosan G. N. however gave a slightly higher reduction up to the 14th week from the time of application. Even at the end of 28 weeks there was a slight difference in favour of Agrosan.

The effect of these two preparations on bacterial infection was somewhat different. The treated seeds were free from bacteria till the 8th week. Agrosan G. N. gave a higher reduction up to 14 weeks but the figures obtained after 28 weeks showed no effect of any of the two disinfectants. The bacterial growth in all cases was so vigorous that it might have masked the growth of fungi to a considerable extent.

Eelworms.—***Effect of Methyl Bromide fumigant***—In 1952 the effect of Methyl Bromide on the control of Eelworm in soil was tested at Tocklai in an area which was known to be infested by the pest. The fumigant was used at 50 lbs. and 100 lbs. per acre as recommended by the suppliers. The concentrations were however considered to be too low for the purpose.

Another experiment was therefore carried out, at Limabarie Tea Estate, Darrang, with the kind co-operation of the Manager of the estate, using Methyl Bromide at 4 different concentrations varying from 100—400 lbs. per acre.

20 nursery beds of 6′ x 6′ were prepared in November and the following treatments were applied in the 3rd week of January.

1. 4 randomised beds of 6′ x 6′—One ampoule of 20 cc Methyl Bromide @ 100 lbs. per acre crushed at the centre of each bed at a depth of 9″ from the surface.
2. 4 randomised beds of 6′ × 6′—Two ampoules of 20 cc Methyl Bromide @ 200 lbs. per acre crushed at equal distance in each bed (i. e., 2′ × 3′ apart) at 9″ from the surface.
3. -do- -do- —Three ampoules of 20 cc Methyl Bromide @ 300 lbs. per acre crushed at equal distance (i. e., 2′ × 2′ apart) at 9″ from the surface.
4. -do- -do- —Four ampoules of 20 cc Methyl Bromide @ 400 lbs. per acre crushed at equal distance (i.e., $1\frac{1}{2}'$ × $1\frac{1}{2}'$ apart) at 9″″ from the surface.
5. -do- -do- —As control.

The beds treated with Methyl Bromide were covered immediately after crushing the ampoules with rubber sheets. The covers were removed after 24 hours.

Initial estimation of the pH and Eelworm population of the area as a whole was made prior to treatment.

After 3 weeks of fumigating the soil, each bed was sown with 50 pre-germinated seeds.

Observations made after $6\frac{1}{2}$ months from the date of sowing gave the following results.

Treatments	Eelworm per 10 gms. of soil		pH		Total seeds planted	Total seeds emerged	Total No. of seedlings affected by Eelworms	% Free from attack	Average length of plants including roots in inches	Average weight in gms.
	Initial	After $6\frac{1}{2}$ months	Initial	After $6\frac{1}{2}$ months						
1	13	2	6·07	5·56	200	74	68	8	10·6	3.5
2		2		6·27	200	65	36	44	12·9	4.0
3		4		6·00	200	104	40	61	14·6	4.3
4		4		6·54	200	128	48	62	14·4	3.9
5		5		5·73	200	102	84	17	12·1	3.2

Although Methyl Bromide at 200-400 lbs. per acre reduced Eelworm infestation by about 40-60% it was not effective in eradicating the pest completely even at 400 lbs. per acre.

Seasonal variations at different soil depths—An experiment was started in 1952 to find out (1) whether there is any difference in the Eelworm population at different soil depths and (2) whether there is any seasonal variation.

Fortnightly samples drawn from 1"-6", 6"-12", and 12"-18" from a site known to be infested by the nematode were examined during 1952 and 1953 and the number of Eelworms per 10 gms. of soil was recorded in triplicate.

The results as worked out by the Statistician are given below.

TABLE I

Depth	Season	Jan.		Feb.		March.		April		May		June		July		August		September		October		November		December		Total
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	
1"-6"	1952	3	9	11	14	9	4	2	9	4	5	11	11	6	10	5	3	5	6	7	5	9	11	12	5	176
	1953	16	4	5	5	1	3	8	5	4	4	12	4	3	2	5	4	3	9	2	5	4	4	6	5	123
TOTAL ...		19	13	16	19	10	7	10	14	8	9	23	15	9	12	10	7	8	15	9	10	13	15	18	10	299
6"-12"	1952	9	11	2	4	1	11	11	8	3	1	4	5	2	5	4	1	1	4	2	3	4	8	9	6	119
	1953	8	3	2	1	1	3	3	5	4	3	4	3	1	1	5	3	6	4	3	2	0	3	3	5	76
TOTAL ...		17	14	4	5	2	14	14	13	7	4	8	8	3	6	9	4	7	8	5	5	4	11	12	11	195
12"18"	1952	0	1	0	1	22	1	1	2	2	1	1	1	1	0	1	1	0	1	5	1	1	3	4	3	54
	1953	2	2	2	0	0	1	2	1	2	0	3	1	1	1	5	2	3	1	1	1	0	1	8	2	42
TOTAL ...		2	3	2	1	22	2	3	3	4	1	4	2	2	1	6	3	3	2	6	2	1	4	12	5	96
Interval Totals ...		38	30	22	25	34	23	27	30	19	14	35	25	14	19	25	14	18	25	20	17	18	30	42	26	
Month Totals ...		68		47		57		57		33		60		33		39		43		37		48		68		590

TABLE II.

Analysis of variance

Variance due to	Sum of Sq.	D of F.	Mean Square
Total ...	1889.528	143	13.213
Aggregate ...	1079·640	71	15.205
Month ...	147.300	11	13.57
Interval ...	8.040	1	8.04
Depth ...	429.348	2	214.674***
Month X Interval ...	69.630	11	6.33
Month X Depth ...	247.492	22	11.25
Interval X Depth ...	25.552	2	12.776
Error (A) ...	152.278	22	6.921
Season ...	81.000	1	81.00**
Season X Month ...	175.340	11	15.94
Season X Interval ...	9.000	1	9.00
Season X Depth ...	19.042	2	9.521
Season X Month X Int. ...	123.300	11	11.21
Season X Month X Dep. ...	171.118	22	7.778
Season X Interval X Dep. ...	10.264	2	5.132
Error (B) ...	220.824	22	10.037

***Means significant at less than 1% level of probability.
**Means significant at 1% level of probability.

S.D. Between depth total $= \sqrt{6.921} \times \sqrt{2} \times \sqrt{48} \times 2.074$

$= \sqrt{41.526} \times 8.296$

$= 6.444 \times 8.296$

$= 52$

S.D. Between Season Totals $= \sqrt{10.037} \times \sqrt{2} \times \sqrt{72} \times 2.474$

$= 3.168 \times 24.888$

$= 79$

TABLE III.

Total Eelworms per quarter during 1952 & 1953.

January-March	April-June	July-September	October-Dec.
172	150	115	153

Conclusion —The Eelworm concentration decreases with depth. Eelworms in the top 6′ soil are significantly more in number than in either the 6″—12″ or 12″--18″ soil. The number in the 6″-12″ soil are also significantly higher than that in the bottom part.

Season. —Significantly more Eelworms were found in 1952 than in 1953. There is further seen an upward trend of the occurrence of more Eelworms in the quarter January-March and October-December, vide Table No. III.

Other factors.—Other factors have not produced any significant effects.

Advisory. 389 specimens of fungus diseases were examined and reported on.

48 samples of soil from proposed nursery sites were received from outside and examined for Eelworm infestation.

312 letters and memoranda were issued in connection with diseases.

9 samples of fungicides were received for trial.

Publications.—The following Tea Encyclopaedia Serials were revised.

1. Hail damage on Tea Estates—Serial No. 36/1 under I.4. (jointly by Agriculturist, Senior Advisory Officer Assam Valley and North Bank and Mycologis)

2. Control of Pests and Diseases of Boga medeloa Serial No. 44/1 under E. 1 (jointly by Entomologist and Mycologist.)

3. Branch Die-back and Nectria—Serial No. 65/1 under I.3. (jointly by Mycologist and Senior Advisory Officer, Assam Valley and North Bank).

4. The Prevention and Cure of Red rust—Serial No. 61/1 under I.4. (Jointly by Mycologist and Senior Advisory Officer, Assam Valley and North Bank).

Touring.—The Mycologist visited 18 gardens in the Dooars, 5 gardens in Upper Assam and 9 local gardens.

Advisory Branch : Assam Valley

Staff.—Senior Advisory Officer, Assam—P. M. Glover, M.B.E., B.Sc.

Advisory Officer—E. D. Heath, B.Sc.

Mr. E. D. Heath joined the Advisory Branch on 22nd October, 1953, and began his training under the Agriculturist.

Touring and Meetings.—During the year the Senior Advisory Officer, Assam, paid the following visits to gardens :

Assam Valley.

Jorhat Circle	... 12 gardens.
Golaghat Circle	... 4 gardens.
Doom Dooma Circle	... 13 gardens.
Panitola Circle	... 13 gardens.
Dibrugarh Circle	... 5 gardens.
Moran Circle	... 2 gardens.
Tingri Circle	... 7 gardens.
Nazira Circle	... 3 gardens.
Nahorkatiya Circle	... 10 gardens.
Nowgong Circle	... 7 gardens.

North Bank.

Tezpur Circle	... 8 gardens.
Borsola Circle	... 10 gardens.

The Senior Advisory Officer, Assam, attended the Annual General Meeting of the Assam Branch Indian Tea Association held at Panitola on 21st November, 1953.

Surma Valley.

The Senior Advisory Officer, Assam, attended the Annual General Meeting of the Surma Valley Branch Indian Tea Association, at which he represented the Director and addressed the Meeting. One garden in Cachar was visited.

East Bengal.

The Senior Advisory Officer attended the Annual General Meeting of the Pakistan Tea Association, at which he represented the Director and addressed the meeting. Opportunity was taken to visit 5 gardens in East Bengal.

A tour of the Surma Valley was arranged for 17th September to 24th September by the Secretary Surma Valley Branch Indian Tea Association for the Senior Advisory Officer, Assam. This tour had to be cancelled by the Surma Valley Branch due to severe flooding.

A total of 100 gardens were visited during the year many of which were visited on several occasions in connection with experiments or field trials in progress.

Lectures.—The Tocklai Annual Lecture Courses were held from 23rd February to 29th February and 2nd March, to 7th March 1953. On each course the Advisory Officer, Assam lectured on "Application of Pest and Disease Control Measures on Tea Estates". A demonstration of spraying machinery also was given on each course.

The Senior Advisory Officer also lectured on "The Principles of Pest and Disease Control in the Tea Industry" to the Degree students at the Assam Agricultural College, Jorhat.

Publications and Tea Encylopaedia.—A report on a visit to South India by the Senior Advisory Officer Assam was published as Memorandum No. 23. A new Serial in Tea Encyclopaedia No. 98 on "Safety Precautions with Air Pressure Retaining Knapsack Sprayers" was published in conjunction with the Resident Engineer.

During the year the following Tea Encyclopaedia Serials were re-written and published.

Serial 36/1 under I.4 "Hail Damage on Tea Estates" with the Agriculturist and the Mycologist.

Serial 43/1 under L.4 "Infilling and Treatment of Infills" with the Agriculturist.

Serial 53/1 under G.1 "Medium Pruning" with the Agriculturist.

Serial 40/1 under E.2 *"Crotaria anagyroides"* with the Agriculturist

Memoranda.—Over 518 Memoranda were issued during the year as result of visits to gardens or in answer to correspondence.

Storm Damage to Shade.—A violent cyclonic storm occured in the Dibrugarh, Panitola, Tingri and Doom Dooma districts on the night of 12th/13th August. Extensive damage to shade occurred throughout the area, which was, in general, worse in gardens lying to the North of the district along the Dibru river.

The Senior Advisory Officer Assam visited the above areas between 24th and 27th August and was also able to survey the damage from the air through the courtesy of Mr. R. C. Reynolds, Esqr., O.B.E. of Sealkottee T. E.

A report was prepared entitled "Storm Damage to Shade Trees in the Dibrugarh, Panitola and Doom Dooma Circles" containing an account of the damage with recommendations as to the actions to be taken. This report was circulated to all gardens affected by the storm.

Multi-level N. P. K. Experiment.—An NPK experiment replicating all levels of NPK utilised in the experiment now being laid out at Borbhetta, is being laid out at Panitola T. E. with the co-operation of the Scientific Officer, Jokai (Assam) Tea Company.

The area is shaded with medium sized Sau *(A. stipulata)* and young *A. odoratissima*, there being one of each in each plot. Plot size 11 × 11 bushes 0.0445 acres.

There are 54 treatments with two repeats total of 64 plots in two blocks of 34 plots each.

Treatments are :

NO PO KO	N40 PO KO	N80 PO KO	N80 P40 K20
NO PO K40	N40 PO K40	N80 PO K20	N80 P40 K40
NO PO K80	N40 PO K80	N80 PO K40	N80 P40 K80
NO P40 KO	N40 P40 KO	N80 PO K80	N80 P80 KO
NO P40 K40	N40 P40 K40	N80 P20 KO	N80 P80 K20
NO P40 K80	N40 P40 K80	N80 P20 K20	N80 P80 K40
NO P80 KO	N40 P80 KO	N80 P20 K40	N80 P80 K80
NO P80 K40	N40 P80 K40	N80 P20 K80	
NO P80 K80	N40 P80 K80	N80 P40 KO	

It is hoped to repeat this experiment on the North Bank at a later date.

N. P. K. Experiments.—Two experiments were started at Bindukuri T. E. on the North Bank in 1937 to detect any detrimental effect which might arise over a period of years from the application of an unbalanced fertiliser (i. e. one supplying nitrogen only) to tea. All manuring was stopped from 1944 to 1947 due to war time shortages. In 1948, as no Superphosphate was available, only N and K were applied. In 1949 full manuring was begun again, for the first time since 1943, at the following rates :

N 120-P 40-K 40.

In both experiments in the years 1952 and 1953 N and NP gave returns greater than from the check plots, though in X70 in 1953 the difference just missed significance at the 5% level. In no instance was the yield from NP significantly better than from nitrogen alone.

There is a definite indication that Potash depresses crop, in the presence of nitrogen in both years in both experiments, although the extent is not significant at the 5% level.

The depressing effect of K in the presence of nitrogen appears to be counteracted by P though yields from NPK are no better than from nitrogen alone.

Manuring on Bheel Soils.—An experiment is in progress at Sephinjuri Bheel T. E. in Cachar conducted by the Scientific Officer Jokai (Assam) Tea Company.

Treatments are :

NO PO K0	N1 PO K0	N1 = 40 lbs. N per acre
NO P1 K1	N1 P1 K1	P1 and K1 = 40 lbs. P or K per acre.
NO P1 K2	N1 P2 K2	P2 and K2 = 80 lbs. P or K per acre
NO P2 K3	N1 P2 K3	K3 = 120 lbs. K per acre.

In the first year of the experiment there was no statistical difference (5% level) in yield between any of the treatments.

In 1952, nitrogen alone gave no increase in yield. Potash at 80 lbs. K_2O per acre gave a significant increase in yield in the presence of phosphate at 40 lbs. P_2O_5 per acre (N0P1K2). Potash alone might well produce an equally beneficial effect, but this cannot be determined from the particular layout of this experiment. Nitrogen tends to depress the beneficial effects of high levels of P and K, but appears to exert no effect on lower levels. There is no significant difference in the beneficial effect of P1K2 and P2K3.

While it would be most unwise to draw any definite conclusions from these figures, until further evidence is available a P1K2 mixture is suggested for Bheel soils as a temporary measure.

Ordinary Superphosphate	(20%)	... 200 lbs.	per acre.
Muriate of Potash	(50%)	... 160 lbs.	

At Bhubandhar T. E. on a Bheel soil calcium sulphate at 1 oz. per bush did not have any beneficial effect.

Inorganic and Organic Fetilisers. –(a) An experiment started at Halem T. E. in 1933, is now in its twenty-second year. Treatments are :

Control	...	No manure.
Cattle manure	...	200 mds. (16,000 lbs.) per acre.
Inorganic Fertiliser	...	N 40 as Sulphate of Ammonia P 20 as Superphosphate K 20 as Muriate of Potash.

In both 1952 and 1953 both treatments gave yields significantly greater at the 5% level than the check plots. In 1952 the inorganic mixture gave a yield significantly greater than the cattle manure but in 1953 the difference was not significant.

(b) An experiment started at Jamira T. E. in 1948 is now in its sixth year. Treatments are :

Control	...	No manure.
Oilcake	...	80 lbs. nitrogen per acre.
Sulphate of Ammonia	...	80 lbs. nitrogen per acre.

In each year 1949 to the present time, both treatments have given yield significantly greater than from the check plots.

In 1949 and again 1953 the yield from sulphate of ammonia was significantly greater (5% level) than that from oilcake ; in other years differences have not been significant.

Shade, Nitrogen, and Plucking. –At Hunwal T. E. this experiment is now in its seventh year. Treatments are :—

Two levels of N ... 40 lbs. and 120 lbs. per acre.
Two tipping heights ... 6" and 9"
Shade and no shade.

The tea is Betjan and the shade is now very light indeed ; it has deteriorated considerably in the last two years. In both 1952 and 1953 the overall effect of nitrogen has been a gain of 6½ mds. per acre, and with this very light shade the differences in increase from the shaded and unshaded plots have not been significant at the 5% level. Nevertheless the overall gain from shade amounted to 4½ mds. in 1952 and 3½ mds. in 1953. The higher yield from the higher level of nitrogen from the unshaded plots was not significant at the 5% level in either year.

Difference in plucking level had no significant effect in either year.

Shade and Manuring.—Eight experiments on shade and manuring are in progress on gardens on the North Bank.

Spraying of Shade with Minimax Fire Extinguishers.—At the suggestion of a West Bengal Planter received through the Senior Advisory Officer, West Bengal, a preliminary trial was made of the possibility of spraying shade trees with a Minimax Fire Extinguisher charged with DDT.

The normal period of discharge of a Minimax is 30 seconds, and the fluid leaves the machine in a concentrated jet. By placing a finger over the nozzle when moving from one tree to another, it was possible to spray 4-5 trees in about 2 minutes. The spray cover was not satisfactory, and the cost per tree disregarding cost of labour and insecticide worked out at Rs. 1 12 (medium sized (*Derris robusta*). This method of spraying shade is not considered to be promising.

The Universal Major Sprayer.—This spraying machine manufactured by Messrs. Pest Control, Cambridge, is designed to work from a road, and to be towed behind a tractor. Its pump is driven from the power take off of the tractor and the spray fluid is fed to long rubber hose pipes.

The Senior Advisory Officer, Assam, was invited to a demonstration of this machine by the courtesy of the Superintendent and the Scientific Officer, Jorehaut Tea Company :

> A very rapid spray cover can be obtained along either side of a road wide enough to allow the passage of a tractor. The depth covered on either side of the road is approximately 60-70 feet, and at full stretch (60') the hose requires three labourers to hold it off the surface of the tea bushes. The spray fluid is delivered at high pressure at the nozzles, approximately 150 lbs. per square inch. No attempt is made to spray individual bushes, the labourer in charge of the spray lance moves within his 70' strip from the road, spraying small areas of bushes, and with this high pressure considerable penetration of the top hamper is obtained. A small proportion of bushes may be omitted or fail to receive an adequate cover but where speed is the main essential as it frequently is, in the case of epidemics and where the garden is well roaded, such a machine has the great advantage of speed, without the use of excessive labour or spray fluid. For Red spider, which is always most prevalent along roadsides and for such pests as Tea mosquito, Green fly (*Empoasca flavescens*), Pink mite, Looper caterpillar and Blister blight which occur mainly on the top hamper leaf of the tea bush, such a machine has a definite value. It would always require the complementary use of Knapsack sprayers for such areas as are more than 60' from a road negotiable by a tractor, and also for all areas remote from such roads.
>
> A machine of this type is of little use against Black rot, where a full frame spray is required, or against Red rust where a full cover of all shoots arising below the pruning table is essential, as individual bush

spraying, which those treatments demand, would undoubtedly be very slow indeed, with a machine of this kind based on a road, and feeding spray to lances by means of long hoses.

The Universal Major is both expensive and cumbersome. It is believed that very satisfactory results would be obtained by using an ordinary "Plantector" type sprayer mounted on the hydraulic lift of a tractor, in the manner described. Some minor modifications would be required. These will be discussed by the Senior Advisory Officer, with firms making this type of equipment, when he is in the U. K. on leave this year.

A preliminary report on the Mysto sprayer.– This outfit, consisting of one Central Charge Pump and six air pressure retaining pneumatic knapsack sprayers, was received for trial from Messrs. W. T. French & Sons Ltd., Birmingham, England.

The Charge Pump is in all its main features exactly similiar to Messrs. Vermorel Favori-Colibri's Charge Pump. As designed at present, the pump is not strong enough to stand up to the hard wear which it is likely to encounter on tea gardens. The valve system is also faulty.

Initial charging the knapsacks with air to 40 lbs. per sq. inch is done with an ordinary Dunlop motor car foot pump via a Schraeder valve, and takes about 5 minutes.

Fluid was pumped in with a Favori-Colibri pump. To charge to 110 lbs. per square inch air plus liquid pressure took 2 minutes and at this pressure the total fluid content was approximately 2 gallons. The spray nozzle is Messrs. Watsons & Co. Fan-Jet C·60 and is entirely satisfactory.

A report has been sent to the makers who have intimated that our suggestions have been incorporated and our criticisms met in their new Mark I model which is now on its way out to us.

Preliminary trials witb Messrs. Drake & Fletcher Mistifier.—The latest model differs from the original in that a plastic bag, claimed to be resistant to spray chemicals, is fitted inside

the container. All liquid is contained in this bag and there is therefore no contact between spray fluid and container, the air being held between the outside of the bag and the metal canister. Air is charged through an ordinary Schraeder motor tyre valve. The old "blow of" safety device has been replaced by a spring loaded fully automatic relief valve, set to release air, at a pressure slightly above the recommended working pressure.

The initial air charge (40 lbs. per sq. inch) was pumped into the container with an ordinary small size motor car foot pump. The time taken to do this was 4 minutes. This method of charging air is very satisfactory.

The outlet tap to the spray lance is spigot type and the charging hose connection is screw-on pattern. Replacement of the present spigot tap by a wheel type tap, and the fitting of a bayonet connection for the charging hose have been recommended.

The container is light and easy to use. Tests over a prolonged period will be required to determine how the plastic bag will stand up to continuous use with different spray solutions.

The Central Charge Pump is a single cylinder hand operated pump fitted with its own pressure gauge and air pressure valve. It is made of aluminium except the pump cylinder which is brass. It is light and easily carried by one man. It is not used to charge air into the container, this being done as already described via a Schraeder valve on the canister, using an ordinary motor car foot pump.

The recommended combined air plus liquid pressure is 110 lbs. per sq. inch and at this pressure the container holds approximately 2½ gallons of fluid. The pump is quite efficient and to charge 2½ gallons takes 1½ minutes.

There are a number of mechanical faults in this pump as at present designed which have been taken up with the manufacturers.

The Swingfog Pest Control Unit.—The Swingfog Pest Control Unit manufactured by Messrs. Swingfire Ltd. 25, Caxton Street, London S.W.1, was supplied to Tocklai by the courtesy of Messrs. Jardine Henderson,

The apparatus works on an entirely new principle and is quite unlike any other spraying equipment tested by the Scientific Department. It is not actually a sprayer at all being more closely allied to a fog or smoke generator.

The explosion of a small charge of petrol vapour in a combustion chamber propels a stream of hot gas along a tube where it strikes a drop of oily insecticide, which is immediately vapourised and ejected, in the form of a dense smoke. The pressure wave is automatically followed by a wave of reduced pressure which is sufficiently strong to operate a non-return valve to admit a fresh charge of air, at the same time drawing in the required amount of petrol from a simple carburettor. The mixture explodes automatically in the hot combustion chamber, and the cycle is repeated some 80 times each second.

The machine is started by connecting a 6-volt car battery to the terminals of a glow-plug for some 15 seconds. Fuel is then switched on and the vapour fires. The battery is then disconnected. There is only one moving part. When the machine has been running for some 2 minutes, insecticide is injected automatically into the end of the "exhaust pipe", and a dense fog is immediately given out.

A bad attack of Looper caterpillar (*Biston suppressaria*) afforded an opportunity to carry out field trials.

Smoking in the middle of the day under the conditions appertaining in Assam is NOT satisfactory. Smoke tends to pillar very rapidly and then to disappear. The optimum times are early morning and late evening. There is no blast of air from the machine and it will not project smoke over any distance ; reliance must be placed on a light breeze to carry the smoke where required.

Special insecticides designed for use with the Swingfog Pest Control Unit were not available. From a study of the literature it appeared essential to use an insecticide dissolved in oil.

Two insecticides were tested :

1. 5% DDT in oil—prepared by dissolving 1lb. of 5% DDT water dispersible DDT in Diesel oil, to which a few ccs of benzol had been added. (5% is the limit of solubility of DDT in Diesel oil)

2. "Spry Spray" a proprietary insecticide sold by Messrs. General Export Company, Calcutta, stated to contain DDT and Pyrethrum, in a light oil, probably kerosene.

The 5% DDT in Diesel oil produced clouds of dense white smoke : the smoke cloud produced by "Spry Spray" was much less dense and it was not easy to maintain an even cloud.

The apparatus is not unduly heavy (34 lbs. filled) though the carrying sling is too narrow. The method of use was to carry the machine down roads and paths bordering sections such that the wind direction was across the road and towards the tea. The smoke produced was thus carried across the tea by the wind.

The smoke is susceptible to the slightest vagaries of the wind, and an even cloud was never obtained when the machine was used with the nozzle held over the tea bushes. Smoke changed direction, or pillared with every little change in wind direction or intensity, even in the early morning and late evening.

It soon became clear that optimum results were obtained when the machine was held so that the nozzle was inserted almost at ground level between the canopies formed by successive rows of tea bushes and held there for a few seconds before passing on to the canopy between the next pair of bushes, and so on.

The machine behaved perfectly and started without any trouble whatsoever. When shutting off at the end of operations the insecticide tap must be closed prior to closing the petrol tap, otherwise the insecticide may catch fire at the end of the fog mixing tube (nozzle).

Under optimum conditions, i. e, early morning and late evening, using the machine as described in the previous paragraph the smoke penetrates beneath the first 2-3 bushes (i. e. 10-14 ft.) from the roadside or path and is really dense. It drifts beneath bushes up to about the 7th or 8th bush (i.e. 30-40 ft.) becoming progressively less and less dense until at about the 7th-8th bush it forms a very light mist.

The smoke from beneath the first few bushes rises rapidly through the frame and top hamper in a dense cloud ; that from beneath bushes further in, rises similarly but in a progressively thinner cloud. On reaching the air above the bush canopy the immediate effect is to pillar. Then, if wind conditions are ideal, the smoke cloud is caught and carried downwards and drifts in a cloud over the surface of the tea bushes becoming more dispersed and less dense. This cloud is subject to the slightest vagary of the wind as already described.

No attempt could be made in these preliminary trials to estimate whether any pesticide was deposited on the leaves of the tea bushes. *The impression gained however is that there was little if any deposit of pesticide even on bushes close to the roadside where the smoke cloud was heaviest.*

If this is the case the insecticide can have only a fumigating effect. The period of contact at the very maximum did not exceed 30-45 seconds. It seemed improbable that 5% DDT would have a sufficient fumigatory effect to cause mortality in so short a time.

In areas sprayed with 0.25% DDT, a considerable reduction in Looper incidence is observed within 24—48 hours. No reduction of Looper incidence was observed on the two days following treatment with the Swingfog even on bushes which received a full measure of smoke.

Thereafter, unfortunately from the point of view of these trials, an unforeseen factor (Bacterial disease) took a hand in destruction of Looper caterpillar throughout the garden and it was not possible to estimate whether mortality was the result of bacterial disease or the result of treatment.

The insecticide tank on the Swingfog holds about 7 pints of insecticide and the petrol tank 1 quart petrol. One fill of insecticide provides about 20-25 minutes smoking. It is assumed

that the area treated in depth is that distance to which the smoke penetrates beneath the bushes, disregarding the area over which the smoke drifts across the bushes. This latter area in any event varies so widely with wind behaviour as to be indeterminable.

The area treated, (as defined above) with one fill of insecticide (7 pints) was approximately 220 yards in length and 30-40 ft. in depth or very approximately ½ acre; time taken 20-25 minutes.

The leaf from the 1st to 8th bush onwards inclusive from the smoked area was plucked and manufactured separately. Leaf from these bushes was chosen as it was here that there had been maximum contact between smoke and leaf. Teas manufactured from this leaf were tested at Tocklai by our Tea Taster. No taint was discerned.

Short summary of results obtained.

1. The Swingfog is easy to handle and manipulate. No mechanical difficulties occurred.

2. Using 5% DDT in Diesel oil, a dense smoke cloud was produced.

3. Optimum times for use are early morning and late evening. Midday smoking is not satisfactory due to pillaring. The machine must be used to smoke downwind.

4. With one fill of insecticide 7 pints, it was possible to envelope in smoke ½ an acre of tea in 25 minutes using the technique described. Roadside bushes only can be treated.

5. No taint could be found on tea manufactured from leaf plucked from bushes so smoked.

6. Insecticidal action did not appear to be effective but results were inconclusive due to the appearance of a bacterial disease of Looper caterpillars, which caused high mortality.

Selective Weed Killer Trials.—These trials were begun in 1952 at Bokahola T.E. on a very poor area of old uprooted tea (1950) allowed to revert naturally to thatch.

Treatments were :

Control

Fernoxone (2, 4 D) at 2½ lbs. per acre.

Chloroxone (2, 4 D) at 2½ lbs. per acre.

Agroxone (MCPA) at 0.275 gallons per acre.

2, 4, 5 T at 0·4 gallons per acre.

Half the plots were sprayed at high volume (120 gallons per acre) and half at low volume (24 gallons per acre) using air pressure retaining knapsack sprayers.

Low volume proved to be as effective as high volume in the case of all materials except Chloroxone. This is believed to be due to the poor solubility of this product.

Agroxone proved no better than control. Both Fernoxone and Chloroxone resulted in a considerable increase in thatch ; 2, 4, 5 T was almost twice as effective as either Fernoxone or Chloroxone.

These trials were repeated in 1953, but as thatch growth was very uneven thatch roots were planted in roughly made lines after burning off in the cold weather of 1952-53 in those areas devoid of thatch or where thatch was very sparse.

In view of the previous year's conclusion that low volume was equally effective as high, only low volume spraying was done. The application rate was 20 gallons per acre and all spraying was done with a "Plantector" type sprayer mounted on the hydraulic lift of a Ferguson tractor.

Treatments were :

Control

Fernoxone (2, 4 D) at 2½ lbs. per acre.

Agroxone (M. C. P. A) at ½ gallon per acre

2. 4. 5 T at $\frac{1}{2}$ gallon per acre.

2, 4, 5 T at $\frac{1}{4}$ gallon per acre.

2, 4, 5 T plus Fernamine (2, 4 D) in equal parts 3 pints at per acre.

All treatments gave an improved yield of thatch. Agroxone was the least effective treatment. 2, 4, 5 T + Fernamine was less effective than 2, 4, 5 T alone at either rate. 2, 4, 5 T is as effective at $\frac{1}{4}$ gallon per acre as at the higher rate. 2, 4, 5 T at $\frac{1}{4}$ gallon per acre and Fernoxone at $2\frac{1}{2}$ lbs. per acre were the most successful treatments.

The general conclusion is that where the majority of weeds are soft and non woody, (eg. *Ageratum* sp.), Fernoxone at $2\frac{1}{2}$ lbs. per acre is advised. Where the majority of weeds are of a woody nature (eg. *Urena* sp., *Rubus* sp., *Melastoma* sp.) 2, 4, 5, T at $\frac{1}{4}$ gallon per acre will give the better result.

19. ***Nectria.***—A visit was paid to Panitola and Tippuk T.E.s by the Mycologist and the Senior Advisory Officer and the Scientific Officer of Jokai (Assam) Tea Co. Ltd. to make a joint investigation of the *Nectria* experiments now in progress.

Examination of 3-year plants and of 2-year old wood on young vigorous tea inoculated with parasitic Tippuk *Nectria* sp. showed that no infection had taken place. It would appear that young stems up to 2 years are not susceptible to parasitic *Nectria* attack.

The experimental plots at Tippuk consist of 4" rows of 6 bushes. One plot had been medium pruned at 24" each month commencing from September 1952 and a number of pruning cuts had been inoculated with cultures of both types of fructifications, viz., pink conidia (probably *N. ochroleuca)* and red perithecia (parasitic *Nectria* Tippuk strain). Fungicidal treatments have been applied immediately, 24, and 48 hours after inoculation.

Examination of all inoculated cuts on the plots from September to February showed that :

(a) Cuts inoculated with cultures of pink conidia (probably *N. ochroleuca*) were not infected.

(b) Cuts inoculated with cultures of Red perithecia (Tippuk strain) only, showed a certain amount of infection which appeared to vary according to the initial starch reserves in the roots of the bushes concerned.

There were more infected cuts on bushes which contained low reserves in their roots. Bushes which contained fair to good starch reserves at the time of inoculation either had no infection or, where some of them had been infected, the disease did not extend very far.

The tea outside the experimental area, but adjacent to it, carried a moderate to heavy infection of *Nectria* about 2 years ago. This tea is now making vigorous growth and most of the disease is now disappearing.

From this it would appear that there is a direct relation between starch reserves (i.e. the health and vigour) of the bush and the extent of infection and of damage by the disease. Strong and healthy bushes are resistant to infection to a great extent and are capable of throwing off the disease if they do become infected. Weak bushes are more susceptible to infection. This conclusion is supported by experiments carried out at Tocklai.

In view of the most interesting results already obtained it has been decided to continue the experiment with certain modifications.

(a) Every month commencing from March 1954 in two plots one of healthy and one of weak tea, a number of shoots will be pruned at 24" and the cuts inoculated with fresh cultures of Tippuk *Nectria* (red), the plots to be laid out and pruned early in the autumn 1953 so as to induce early growth in the spring. Weakness will be induced by slashing off the first flush and leaving the tea unmanured. To produce vigour plots will be manured with 80 lbs. nitrogen per acre as sulphate of ammonia and given a full 8" of new growth to the tipping level.

(b) Since fungicidal spraying of hail damaged or pruned tea is not likely to be practicable under tea garden conditions within the first 24 hours of a factor predisposing to disease e.g. hail (except in cases of very small areas) it has been decided to omit treatments during this period. Moreover, it has been observed that infection of wounds treated within the first 24 hours in any event is negligible. It is, however, considered that 48 hours would be a reasonable time within which an estate could treat even a fairly large area. A fungicide to be of commercial importance must be effective if applied 48 hours after infection has occurred.

The plots will receive the following treatments on equal numbers of bushes 48 hours after inoculation with Tippuk *Nectria* :

(1) A copper fungicide (at double the usual strength) i.e.0·5%

(2) A mercury fungicide

(3) A tar distillate (5%)

(4) Control.

WEST BENGAL ADVISORY BRANCH

Staff.—R. I. Macalpine, B.Sc.—Senior Advisory Officer, A. D. Swan, B.Sc.—Advisory Officer.

Administration.—The year under report saw the formation of the West Bengal Advisory Branch with headquarters at Nagrakata in the Dooars, consisting of Senior Advisory Officer in superior charge there and an Advisory Officer at Puttabong in the Darjeeling District, whose special responsibilities are the Darjeeling and Terai Districts.

The new organisation came into being with the transfer of Mr. R. I. Macalpine from Darjeeling to Nagrakata, and Mr. A. D. Swan from Tocklai to Darjeeling in May, 1953.

DOOARS ADVISORY BRANCH.

Touring.—Prior to his permanent transfer to Nagrakata as Senior Advisory Officer, the Advisory Officer, Darjeeling and Terai visited during the year, 7 gardens in the Dooars, 7 gardens in the Terai, and 6 gardens in the Darjeeling District.

Since his arrival in the Dooars he has visited 46 gardens in the Dooars, 3 in the Terai and one in the Darjeeling District.

The Mycologist visited the Dooars in March, the Senior Biochemist in September and the Agriculturist in December.

In November Mr. D. W. Tull, Consultant Engineer, I. T. A. London, accompanied by Mr. I. McTear, Resident Engineer, Tocklai, visited the Dooars and Terai where meetings were held at Mal and Bengdhubi to give an opportunity to members to meet Mr. Tull and to hear what work was in progress in connection with mechanisation and engineering problems connected with tea manufacture.

In November the Senior Advisory Officer attended a meeting of the Darjeeling Branch Indian Tea Association to discuss methods of research for the District generally.

The Advisory Officer attended the Annual General Meeting of the Terai Planters' Association, the Dooars Branch Indian Tea Association and the Darjeeling Branch Indian Tea Association.

General.—The year opened with the threat of continuation of the economic crisis which had hit the industry, and this to some considerable extent affected cultural operations during the cold weather.

Apart from economies effected in such items as manuring, cultivation, medium pruning, etc., in many gardens, a short working week had to be introduced. At the start it was apprehended that the latter would result in work having to be extended over periods much in excess of those normally required, and in some cases this was so. The shorter working week was however to some extent counterbalanced by reduced absenteeism and in general cultural operations were not unduly delayed.

The introduction of the voluntary regulation scheme and the emphasis laid on the necessity to improve quality of teas, generally resulted in a departure in some cases from previous normal working. An item of particular interest in this connection was the amount of tea left unpruned in those gardens which are not on an annual pruning cycle. In certain gardens the proportion of unpruned to pruned was reduced. While this under normal climatic conditions would not, it is believed, have resulted in an excessive decrease in overall crop, and would have brought about the desired effect in relation to improving quality, a period of drought after the season had started favourably caused a considerable retardation of growth, and on the whole early season crop suffered badly. Those gardens with a high proportion of unpruned tea were able to benefit to some extent from the start of season crop.

Throughout the season however, the climate was abnormal, and in general the season closed with a considerable shortfall in rainfall, of as much as 40"-60" in some localities. The rains ceased comparatively early, (at Nagrakata Headquarters there was no rain between 4th October and end of November), and in general crops have been below average.

Pathology: (*1*) *Insects & Acarids.*—Red spider *(Metatetranychus bioculatus)* was prevalent in certain localities in a high degree of incidence and persisted late into the season.

Among other pests that were prevalent during the year, were Red slug *(Heterusia magnifica)* and in certain localities both at the beginning and end of the season Tea mosquito *(Helopeltis theivora)*.

A pest of particular importance this year has been *Baradesa omisia* which has caused severe damage to *Derris robusta* shade trees. In certain gardens trees have been defoliated as many as three times in the year and trees have been so severely debilitated thereby, that in a number of cases deaths have occurred.

No satisfactory methods of control appear possible as spraying is both expensive and impractical with present forms of spraying equipment. Moths appear in the evening and during the night and exist in such numbers as to make physical destruction also impracticable.

Pysillidae (Plant lice) attacks were this year not as usual mainly confined to *A. odoratissima*, but extended also to *A. stipulata* and *A. procera*.

In certain Estates control measures by spraying with D.D.T. or dusting with B. H. C. were adopted early on and continued at short intervals of from 7-10 days throughout the growing season. Results have been uniformly good and there can be no doubt that the secret of control lies in taking prophylactic action before seedlings are infested by the lice, and continuous spraying thereafter.

In a certain Estate a high degree of control was effected by the use of an organo-phosphorus chemical, but applications were on every occasion supervised by a responsible officer, a very necessary precaution in view of the toxic nature of the chemical.

Among other pests reported and identified were a Membracid on *A. odoratissima* in the field, and a Capsid on *Crotalaria anagyroides* which was causing a lot of damage to foliage. Complete control was obtained by dusting with B. H. C.

(2) Fungi and Algae.—***(α) Fungi***—In the course of touring more and more evidence of the presence of Root rots in tea came to light.

By far the commonest are Brown Root rot *(Fomes lamaoensis)* and Charcoal Stump rot *(Ustulina Inonata)* but Tarry Stump rot *(Hypoxylon asarcodes)* has been identified in a few localities ranging from the East to the Western Dooars. Hitherto this latter fungus has mainly been associated with Terai foot-hill Gardens, but it is more than likely that it is also prevalent in the Dooars.

The necessity to deal with primary root diseases immediately they are discovered is again emphasised as there are all too many instances of widespread casualties resulting from failure to take timely and efficient action.

It should be remembered in this connection that generally in the Dooars there is a very large proportion of tea of very great age, and a considerable imbalance between old and young tea. The old tea will have to be kept in bearing for many years to come before Gardens can be regenerated, and it is therefore essential to control Root rots as and when they appear.

The Mycologist during his tour of the Eastern Dooars in March drew attention to the incidence of *Poria hyprobrunea* on the frames of bushes, and to the fact that while it was a weak parasite of branches, if not controlled it was likely to invade the collar region and cause eventual death.

The writer has also observed this fungus throughout the Dooars.

Control methods are detailed in Tea Encyclopaedia Serial No. 68, filed under I. 4.

(*b*) ***Algae***—Red rust *(Cephaleuros parasiticus)* has been observed in a number of areas, on both young and mature tea. In certain Gardens the incidence of the disease on mature tea is of particular interest as specimens from affected areas reported on by the Mycologist have disclosed that penetration of the algae had extended to the xylem tissue, and was in a abnormally severe form.

Affected areas are as evident under droughty conditions as under wet ones. A further point of interest is the fact that in affected areas of tea *Albizzia stipulata* also carried the infection.

In one Estate both young *A. stipulata* and *A. odoratissima* were heavilly attacked.

Vegetative Propagation.—Reference has been made in previous reports to a feature in a variety of localities in the Dooars of the abnormality in internode cuttings of the formation of excessive callus (amounting to excrescenses in most cases). A survey of cuttings in further areas has disclosed that this abnormality is not confined to any one particular locality or type of soil, being equally common in the Mal area with its Mal sand soils, Red Bank (as at Nagrakata) and in the grey silt soil of the Kalchini District.

Trials were initiated in the September-October period cuttings in beds situated in Red Bank soils at Nagrakata Headquarters with material obtained (and transported from) an Estate in the Kalchini District.. Unfortunately droughty conditions prevailed immediately after the cuttings were set in the beds, and the casualty rate has been high as there were inadequate watering facilities at Headquarters.

It is of interest however to note that a certain Estate in the Hasimara District which had experienced considerable difficulties hitherto in this respect, was reported on by the Agriculturist during his visit there, to have achieved success this year with April May cuttings and that the September-October cuttings appear also to be normal. It should be noted, however, in this connection that there has been a considerable shortfall in rainfall this year. As excessive callus formation has usually been associated with water-logging it was thought that at least a contributory cause of the abnormality might be the excessive rainfall which occurs in most of the Dooars during the wet season.

If this is the cause, it would be logical to expect that cuttings set in the September-October period would not exhibit this particular feature, as cuttings would normally be commencing to root in a period of little or no rainfall.

At the end of the year surviving cuttings put down both from the material obtained from the Kalchini area (standard Clones 19-29-13, 1-7-1 and 20-23-1), as also from local bushes, were critically examined in this respect. At this state while callus excrescence had not formed, there was nevertheless

evidence of callus formation in excess of that which is normally considered desirable, and it would appear therefore that water-logging, while it may be a contributory cause, is not the only one.

Further study of the problem is required and it is intended to lay down trials to the extent that facilities are available to test not only the question of excessive soil moisture, but also particular soil types and times of taking cuttings.

Green crops : (1) *Tephrosia candida* and *Crotalaria onagyroides*. *Boga Medeloa (Tephrosia candida)* and *Crotalaria anagyroides* continue to be the main green crop species used. The incidence of Red rust on tea, and the known susceptibility of Boga medeloa to the pest, and further, the fact that it can under certain conditions be in an infective stage before the second growing season, has led to it being now held in considerable disfavour. Present recommendations are to remove Boga before the normal sporulation period of the alga, namely April-May. Where Boga only is used this would result in the complete removal of all shade just at that time of the season when damage to the tea plant from insolation is likely to be at its worst. While *Crotalaria anagyroides* has so far not shown susceptibility to Red rust attack, the species has certain disadvantages in comparison with Boga medeloa, the two main ones being its tendency to lodge and its high vigour, which latter characteristic necessitates diversion of labour during the growing season to control it by lopping.

A possible solution to the problem of removing Boga medeloa before the start of the second growing season and still retaining some shade may be in line sowings of mixed seed of *Crotalaria* and Boga (it is tentatively suggested in the proportion of 1 . 2 respectively), seed of each being bulked before sowing. In the following year the Boga medeloa would be removed and the *Crotalaria* left to provide shade.

A point worthy of note in connection with Boga medeloa is that in certain types of soil, e.g. Red Bank, the rate of growth is slow. A number of plants grown in this type of soil at Nagrakata examined at the end of one growing season showed not only poor growth but comparatively little nodule development, whereas two year plants showed high nodule development.

Thus it must be presumed that the "Nitrogen value" of one year Boga under such circumstances is comparatively low, and it is for consideration whether it is worth using the species when *Crotalaria* could be used as an alternative,

Stylosanthes gracilis (Stylo).

A pound of seed was obtained from Ceylon in July 1953 and distributed to certain Estates for establishment mainly of seed multiplication "baries".

At Nagrakata Headquarter, and at a Dairy Farm in the Kalchini District small areas have been successfully established. At Nagrakata Headquarter a small area was put out in the Bungalow vegetable garden. By September the ground was completely covered to the virtual exclusion of other species of plants, in particular "Bagrakote jungle" (*Borreria* sp.) which rapidly invades uncultivated land in this particular locality.

A feature, however, of Stylo is the great ease with which it can be vegetatively reproduced, namely by simply setting lengths of stems in lightly cultivated soil, "anchoring" them down by heaps of soil at the nodes. Although cuttings were put down in September they had by the end of the growing season become well established.

It is of interest to note that in an area which had been sown with lines of Boga Medeloa, cuttings of *Stylosanthes* were placed along the edges.

The cuttings rapidly established themselves but growth was away from the Boga into the interspaces between the lines. This feature, together with the observation that in a corner of the area where cuttings had been put down under the heavy shade of some Ficus elastica trees and where subsequent development was extremely poor, appears to indicate that the plant is a light demander.

A further point of interest is that in spite of the drought which supervened after the 4th October whereas local weed species such as Borreria, Ilami (*Ageratum conyzoides*) and the grasses (including Setaria plicatum, and Thatch), had completely dried out by the end of the year, *Stylosanthes* was still green.

It may be of interest to note that the species was introduced into certain gardens in Darjeeling for trial in 1950, but has unfortunately been lost to sight. A recent Ceylon publication has drawn attention to the possibilities of this species as a soil cover since when a number of enquiries have been received for seed. As it is understood that seed in quantity will be difficult to obtain for some time to come, it is suggested that a means of propagation on an extensive scale could rapidly be achieved by forming multiplication areas from cuttings in the first instance, which in due course could provide both seed and further cutting material. At Nagrakata flowering was observed at the beginning of December, but seed had not set by the end of the year.

Facilities are being afforded for trials on a comparatively extensive scale in a neighbouring Tea Estate where land is being prepared in advance for planting out in the next and subsequent years. The area has been hitherto infested with Borreria and observations will be made to estimate the suppressing effects of *Stylosanthes*.

Dhaincha (*Sesbania aculeata*).

In two separate areas in the Dooars this species was sown for pre-treatment of land for planting. Towards the end of September in both cases the plants started to die out. While this may be due to attainment of natural rotation age, the fact remains that plants in both areas were heavily attacked by Eelworms. Soil samples from one area were forwarded to Tocklai for an Eelworm count which resulted in an incidence average of 24 Eelworms per 10 gms. of soil. In this particular case the soil was taken from an area being prepared for nurseries. The high incidence of Eelworms necessitated selection of an altenative area.

These experiences draw attention to the dangers of introducing new species for such purposes without preliminary trial.

It will be of interest to note that of other leguminous species tried out previously at Kurseong and elsewhere, the

following were observed to be susceptible to heavy Eelworm infestation.

(1). Tephrosia vogellii (African Boga).

(2). Desmodium gyroides

(3). Desmodium laxum

(4). Desmodium sequa

(5). Desmodium pseudotriquetrum.

Priotropis cytisoides. This legume has been tried out in a number of gardens both as a cover crop in mature tea, and as a shade crop in nurseries.

Its growth form in certain localities is not particularly favourable as it tends to throw almost horizontal laterals at a low level but it is considered it would under a coppicing system, be a species suitable for production of cut litter for manuring. It appears to be of comparatively long rotation, and this would be an advantage for this purpose. Untreated stems become excessively woody, but natural leaf litter appears to be considerable.

Darjeeling Advisory Branch.

Administration: The Advisory Officer took up residence in the Puttabong Headquarter, Darjeeling, in May, 1953, on transfer rom Tocklai.

For the first few months no suitable transport for the Darjeeling district was available and touring was of necessity severely restricted. At the end of September, however, delivery of a Land Rover was taken, and touring during the last quarter has been done as and when requested and whenever arrangements could be made.

Touring: During the year the Advisory Officer, Darjeeling and Terai, made the following visits.

Assam Valley:

Four gardens, in the Jorhat Circle, two of these on several occasions in connection with experiments.

Surma Valley :

One garden in the Silchar district and three in the Longai Valley combined with attendence at the Surma Valley Branch Indian Tea Association Annual General Meeting.

Darjeeling :

Darjeeling West Sub District	2 Gardens		
Darjeeling East ,, ,,	6 ,,	5 of these on more than one occasion	
Teesta Valley ,, ,,	4 ,,	1 of these on more than one occasion	
Sonda ,, ,,	1 Garden		
Kurseong ,, ,,	2 Gardens	1 of these on more than one occasion	
Tingling ,, ,,	1 Garden		

Terai :

Two Gardens were visited.

Dooars :

A short visit was made to the Senior Advisory Officer at Nagrakata during June.

Calcutta :

Messrs. I. C. I. & Shaw Wallace were visited in Calcutta when passing through en route to Darjeeling from Tocklai.

Meetings etc : The Advisory Officer attended the following :

Annual General Meeting of Surma Valley Branch Indian Tea Association in February.

Lecture Course in Tocklai during February.

A Terai Planters Association Meeting at Bengdhubi to discuss mechanisation with Mr. Tull and Mr. McTear.

Darjeeling Branch Indian Tea Association monthly meetings on several occasions and meetings of the Darjeeling East and Sonada Sub District.

The Advisory Officer also met the Engledow Commission when in Darjeeling in December.

Whirlwind Junior Duster.—Two trials were made with this machine, one on 11th May at Singla T. E. (Elevation about 1,500 ft.) and the other on 21st May at Gielle T. E. (Elevation about 4,500 ft.)

Dusting was done against Red spider with Guesarol 410-50, i.e. 10% Sulphur with 50% DDT, and Guesarol 405-50, i.e. 5% Sulphur with 50% DDT. The primary object of these trials however was to study the performance of the machine and to develop a technique of using it.

These trials were unfortunately carried out rather late in the year, when conditions for dusting were not at the best. Dusting against Red spider should probably start in February. Conditions at that time of year in the early morning and late afternoon will probably be suitable. Once the S.W. Monsoon starts the weather is very variable and air currents are strong. The choice of day is important and there can therefore be no regular rounds.

The trials were carried out from 6. a.m. to 10. a.m. at Singla and from 4 to 7.30 a.m. at Gielle. On both occasions the weather was clear and sunny (bad conditions for dusting).

Dusting was tried at various positions in the gardens, and directed up hill and down hill. Air currents were variable and success or otherwise depends on these currents being favourable.

Performance.—At Singla, for the first two hours reasonable success was achieved. Dust was found to be fairly evenly spread on the top of the bushes to a depth of 30 yards. However penetration into the bush was not very good. Beyond 30 yards even top cover falls off rapidly.

It was found convenient to divide the section of tea into small blocks about ¼ an acre in extent (chequer board fashion) and dust one block at a time carrying the machine as necessary along the edge of the section and also into the tea.

By this method it was estimated that about 10 lbs of dust were required for reasonable coverage of one acre. This figure is in excess of the maker's claims and was probably due to inexperience in handling the machine and the lack of a sound technique.

Conditions during the trial at Gielle T.E. were difficult. In many cases the air currents were directed down hill. When dusting under these conditions there was little or no settling effect of the dust and much of it was lost into neighbouring jungle or into the neighbouring garden. In many cases it was found that the air current was drifting say uphill over a section but by the time the machine was positioned to dust with the drift the direction of current had changed. This is typical of convexion currents in the hills.

In spite of conditions it was possible to obtain a reasonable top cover but in this case it was found that about 15-20 lbs. dust were required per acre. There was on this trial practically no penetration into the bush.

The machine was found on these trials to eject dust at the rate of approximately 56 lbs. per hour.

It was found inadvisable to fill the container of the machine full, as it is difficult to control the rate of output of dust in the first few minutes. When the machine is approximately half filled it is easier to control output. During the first few minutes the control lever need only be opened about $\frac{1}{3}$ and gradually opened thereafter to its full extent as the container empties. In this way it was found possible to obtain a fairly even output.

Results when dusting down hill or up a very gentle slope were not found to be very satisfactory under the clear weather conditions prevailing, as much of the dust drifts beyond the block of tea without settling.

Conclusion—From these trials the following conclusions can be drawn :

1. That under good weather conditions reasonable top cover with some penetration can be obtained, but the efficiency of the cover against infestation is doubtful.

2. That one acre can be dusted in 10 30 minutes and that from 10—26 lbs of dust are required depending on conditions.

3. That while quicker than spraying or dusting by hand it is doubtful if this method can ever come up to the efficiency of hand methods. Its value lies in the fact that it requires no water and water is extremely difficult to transport in sufficient quantities in this district.

4. That dusting is most efficient when directed up hill with an air current. The barrel of the duster being directed at about 45° or slightly over. (This is Ceylon practice).

5. That the container should only be about half filled, and as the dust is expelled the control lever should be gradually opened to its fullest extent.

6. That dusting the tea in about ½ acre blocks is convenient and ensures a reasonable cover.

Experiments.—The following experiments in the district were continued during the year.

(a) Margaret's Hope T.E. (Maharanee)	N. P. K. Experiment
(b) Kalej Valley T. E.	N. P. K. ,,
(c) Dooteriah T.E.	N. P. K. ,,
(d) Tumsong T.E.	Pruning Cycle Experiment
(e) Mim T.E.	,, ,, ,,
(f) Nagri Farm T.E.	,, ,, ,,

Data for 1953 has not yet been received in all cases. That which has come to hand is being analysed and will be sent to Tocklai in due course for confirmation.

The Times of Pruning Experiment laid out last year at Puttabong and referred to in last year's Report has continued. Initial yields were taken throughout the season. Pruning commenced on 16th November in 4 blocks (one treatment replicated) and was continued on 15th December in another 4 blocks. Pruning will continue on the 15th of each month from now on.

Panighatta Experimental plot.—Cuttings, as follows from Tocklai Standard Clones were obtained from Ambootia T.E. and put down at Panighatta Experimental Plot on 26th June.

Clone	14/29/13	... 263 Cuttings
	20/23/1	... 112 ,,
	1/7/1	... 131 ,,
	Total	... 506 ,,

Seeds of *Albizzia odoratisima* and *Adenanthera pavonina* and of *Crotalaria anagyroides* and Boga medaloa were also planted at Panighatta.

Seed Trials.—During the year germination figure for seeds obtained from Tumsong have been recorded.

One batch of this seed was graded into three sizes, and some split in light and the rest in shade before sowing in germination beds.

Another batch after water testing was stored in a sealed kerosine tin buried underground until March 1953 then graded and put into germination beds.

The following results have been obtained :-

Stored Nov. 1952-March 1953			Sown in Nov. 1953			
			Split in light		Split in shade	
Size	No. Sown	%-age Germination	No. Sown.	%-age Germination	No. Sown.	%-age Germination
Large	100	45	50	60	31	61
Medium	100	56	50	48	50	60
Small.	100	51	50	50	50	44

All seedlings raised from the stored seed have since died,

Seedlings from the other batch have been transplanted with the intention of determining whether "kind" of tea has any relation to size of seed.

Vegetative Propagation :—In May cuttings from 8 bushes in Puttabong were put down. Three of these bushes are thought to be resistant to Blister blight. The others were selected for vigour. One of these Blister resistant bushes—No. 3 in block 21—has been found to be a very good rooter, but the other two have also done reasonably well.

Of the bushes selected for vigour one has proved very difficult to propagate.

Cuttings from bushes also selected for vigour were put down in May, June, July, August and September. There was, of course, only a very small amount of material available on each occasion. On examining a selection of cuttings in each batch it has been found (in December) that those put down in June and July have rooted well and are now making shoots. Those put down in August have rooted but show no signs of shoot formation, while those put down in September have not yet rooted although there is callus formation.

In September cuttings from a pink flowered tea bush from Soom T. E. were put down but have not yet rooted.

Single Bush Manufacture.—Leaf from 26 bushes was manufactured throughout the season and submitted to the Tea Taster for report. Eight of these were reported to have desirable characters.

Pathological.—***Thrips.***—During the year collections of Thrips have been made and forwarded to the Entomologist at Tocklai. Five collections of specimens from tea shoots were sent. However, to date infestation of Thrips on tea flowers has only been slight and only one collection has been made.

A spraying trial against Thrips was carried out in May, on sections of tea in Puttabong T. E. Guesarol 5. 50 in two concentration viz, 4 ozs in 4 gallons water and 2 ozs in 4 gallons water.

Visual inspection of selected bushes in sprayed areas compared with selected bushes in unsprayed areas seemed to indicate a slight decrease in Thrips population. The lower rate of application seemed as effective as the higher.

Aglaospora aculeata.—(Thorny Stem blight) was the most prevalent disease encountered throughout the district. In many gardens it is present to an alarming extent.

Fomes lamaoensis. (Brown Root rot) was found in two estates and has caused considerable casualties.

Ustilina zonata. (Charcoal Stump rot) has been reported from two gardens. In one the disease has attacked large areas of tea and is proving difficult to eradicate.

Tetranychus bioculatus (Red spider) was as usual a serious pest. It is reported to have been one of the worst years for this disease. Evidence of Red spider was again noted in several gardens in December.

ENGINEERING DEPARTMENT.

Staff. I. McTear, Resident Engineer.

Tocklai Electrical Supply. The conversion from 110 volt D. C. to 400/230 volt A. C. supply was taken in hand, in which connection one 55 KW and one 27 KW McLaren/Brush Alternator Sets were installed together with associated switch gear. Suitable alterations were undertaken to the overhead distribution system for supply of three and single phase current as required. This work reached the final stages towards the close of the year and it is perhaps convenient to mention that the change-over was finally effected, on a gradual basis, extending over seven days as from the 1st January, 1954. For the purposes of record it is mentioned that the following buildings have been re-wired :—

(a) Chemical Laboratory.

(b) Agricultural Laboratory.

(c) Main Office.

(d) Bungalow No. 5.

(e) Bungalow No. 6 and the new buildings disignated Bungalow Nos. 9 and 10.

Building Construction.—Design and construction of two new bungalows on the site of the "Bura" bungalow was commenced during the year. One of the bungalows was completed by the end of November and duly occupied. Work on the second building had progressed towards the final stage by the end of the year requiring about a further month for completion.

Tea Machinery Development.—***(a) Experimental Withering Chamber***—This unit was in use during the major part of the season. Apart from some minor trouble the machine fulfilled a most valuable purpose in the investigation of the process of withering of tea.

These investigations were related to the following aspects of withering :

(i) Spreading density of leaf per unit of area.

(ii) Rate of evaporation of moisture for various thicknesses of leaf spread.

(iii) Rate of evaporation of moisture related to hygrometric difference.

(iv) Air velocity.

(v) Spacing of trays or racks best suited to withering of tea in confined spaces using conditioned air at suitable velocity.

The data gained from these experiments provides a sound basis for the development of a suitable unit to meet the needs of commercially processed tea.

Together with work undertaken in connection with the physical withering of tea, ways and means have been studied to facilitate the handling of the leaf between harvesting and rolling. Ideas which have materialised to-date reduce handling of green leaf to spreading for the chemical and physical wither only. Thereafter it is possible to convey and discharge into suitable rolling machines without recourse to further handling.

As an aid to spreading of green leaf and subsequent clearance after withering, a tray has been evolved which is equally suited to factory loft as well as to a Withering Chamber or Tunnel. The tray is simple and inexpensive. It offers a surface for the spreading of leaf which is unimpeded by structural or other obstructions whilst in the matter of discharging leaf, after withering, the simple process of extending the tray for the full length of travel causes it to engage automatically into the pivoting position when the tray can be made to hang vertically thereby allowing the leaf to slide-off. This tray design has been forwarded to the Indian Tea Association, Calcutta for the purpose of arranging Patent cover.

The designing of a Withering Chamber based on the findings of the experimental chamber investigations is now in hand.

Rolling Machinery.—Work has commenced on the making of the continuous action green leaf bruising and twisting machine. Certain experiments will be conducted in order to determine the results arising from certain designs of screw pitches which,

if satisfactory, will be incorporated in the machine now in course of making. It does not seem necessary at this stage to provide a detailed description of the design except to mention that the machine, as indicated by the title, has a continuous action and discharges processed leaf at the top of the machine, some 7′ above surrounding floor level. None of the working parts are visible except the drive pulleys to the various components. A feature of the machine is that it lends itself to an easy arrangement for liquid cooling. There are no out-of-balance working parts which permits good mechanical strength without excessive weight. Floor space necessary is much reduced compared with current designs.

Tea Harvesting by mechanical means.—Certain basic principles were observed towards the close of the season when two "Tarpen" croppers were mounted on a carrier which straddled the tea bushes and operated on rails supported above ground, parallel to the plucking level of two rows of tea bushes. The tea croppers were electrically driven from a 12 volt battery also mounted on the carrier.

First impressions as well as subsequently, on what was admittedly a brief test, proved more encouraging than anticipated. Growth responded equally well, or appeared to do so, when compared with adjacent hand-plucked bushes. As a result of this test, which was in progress during the visit of Mr. Tull, arrangements have been made to produce a suitable power operated harvester in the U. K. It is intended that this machine shall be used at the Borbhetta experimental area in tea planted 4′ × 4′ when the aspect of harvesting of tea by a mechanically propelled harvesting machine can be studied in all its aspects.

Mr. Tull's visit to Tocklai during Oct/Nov. provided considerable impetus to the search for a more practical approach to the development of machines better suited to the tea industry. The occasion was marked by a very full investigation into controlled withering as well as an examination of problems connected with mechanical harvesting of green leaf. Other aspects were also discussed. But as the above two seemed to demand priority of action it was felt that efforts should be concentrated towards this end.

R. P. W.—2000—5-54

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